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BEDSIDE EXAMINATION FOR VESTIBULAR SCREENING IN OCCUPATIONAL MEDICINE

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Abstract
Objectives: The aim of the study was to assess the usefulness of bedside examination for screening of vestibular and balance system for occupational medicine purposes. Study group comprised 165 patients referred to Audiology and Phoniatric Clinic due to vestibular and/or balance problems. Caloric canal paresis of 19% was the cut off value to divide patients into 43 caloric-positive vestibular subjects and 122 caloric-negative patients. The latter group comprised 79 subjects revealing abnormalities of videonystagmographic (VNG) oculomotor tests (central group) and 43 subjects with normal VNG. **Material and Methods:** Vestibular and balance symptoms were collected. Five tests were included to bedside examination: Romberg and Unterberger tests, Head Impulse Test (HIT), Dynamic Visual Acuity (DVA) and gaze nystagmus assessment. **Results:** Vestibular and balance symptoms were reported by 82% of vestibular, 73% of central and 40% of VNG-normal patients. Thirteen out of 18 VNG-normal but symptomatic subjects (73%) had abnormal tests in clinical assessment. The sensitivity of bedside test set for vestibular pathology was 88% as compared to caloric test and 68% for central pathology as compared to VNG oculomotor tests. **Conclusions:** The combination of 5 bedside tests reveal satisfactory sensitivity to detect vestibular abnormalities. Bedside examination abnormalities are highly correlated with vestibular/balance symptoms, regardless the normal results of VNG. Thus, this method should be recommended for occupational medicine purposes.

Key words:
Balance, Videonystagmography, Posturography, Occupational medicine, Vertigo

INTRODUCTION

Vestibular and balance assessment plays an important role in evaluation of workers' ability to work. Jobs like line men / high tension wire technicians, crane operator, window glass cleaners, construction workers and building technicians are jobs that should be evaluated for test of balance. Moving machines may disorientate subjects with vestibular abnormalities because of possible visual-vestibular mishmash. Maintaining balance is a critical factor for work activities that require workers to climb a ladder or even suddenly change position on the ground level.

Although symptoms and medical history are crucial for neurootological diagnosis, more objective assessment is usually required for occupational medicine (OM) purposes.

Balance system collects data from a) labyrinth, which informs about the head position and the angular or linear accelerations exerted on it; b) visual system which informs about position of the objects relative to subject's body, and c) somatosensory system which informs about the relative position of parts of the body. Information from the input organs are processed by central nervous system and

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then sent to cortex to make subject aware of body position; to oculomotor muscles which maintain the visual acuity despite the head movements and along the spinal tract to joints and muscles maintaining balance. Physicians are able to observe oculomotor and spinal responses which are the end part of the nervous pathway. Dix-Hallpike test is used to confirm benign paroxysmal positional vertigo, Unterberger and Romberg gait are the posture tests, Head Impulse Test and Dynamic Visual Acuity test are used to assess vestibulo-ocular reflex stability during eye and head movements.

Romberg test is used in neurology to reveal poor balance of central (cerebellar) or peripheral (vestibular) origin and defects in proprioception. Proprioception sensory receptors are located in the muscles, joints, and skin. Lesions along the dorsal columns of the spinal cord leading to the cerebellum can impair proprioception, giving rise to sensory ataxia and a positive Romberg sign. A peripheral vestibular functional disorder typically causes ipsilateral sways; central syndromes are typically associated with increased body sway forward and backward once the eyes are closed. Romberg test is not specific for vestibular lesions. When posturography is used to estimate the body sway in the quantitative manner, the sensitivity of the test ranges from 40% (dynamic posturography) to 53% (static posturography) for vestibular deficit and 54% for central nervous system disease [1].

Stepping Test, also referred as the Unterberger or Fukuda test, is widely used in neurology and diagnosis of vertigo-associated disease. A number of attempts have been made to validate the Stepping Test as an indicator of peripheral vestibular dysfunction. Both Hickey et al. [2] and Honaker et al. [3] have not been able to significantly distinguish patients with a caloric unilateral weakness from those without while using Stepping Test. Compared to caloric test, Stepping Test was considered as unreliable for peripheral vestibular asymmetry screening. However, patients who fail to achieve sufficient vestibular compensation show a tendency to deviate toward the affected side [4].

Gaze-evoked nystagmus of vestibular origin is direction-fixed, dominantly horizontal nystagmus. The acute vestibular imbalance induces nystagmus visible in direct observation in agreement with Alexander's law, with increasing intensity of the nystagmus in gaze direction of the beat of the nystagmus. Peripheral nystagmus in the subacute and chronic states may be seen with visual fixation removed, but in some subjects very subtle form is likely to be observed. Pure horizontal or down-beating gaze-evoked nystagmus can indicate a structural lesion in the area of the brainstem or cerebellum [5].

Head Thrust Test (the Head Impulse Test of Halmagyi and Curthoys) allows the examination of the horizontal vestibulo-ocular reflex (VOR) which is very useful for detecting imbalance in a labyrinth function although central compensation has occurred. The test is based on a phenomenon that consists of thrusting the head with a low amplitude and high acceleration to one side so that the contralateral labyrinth becomes functionally annulled [5]. Bending the head by 30 degrees increases its sensitivity [6]. This test requires some experience allowing the examiner to observe bits in the end of rapid head movement.

The Dynamic Visual Acuity Test (DVA) is used to measure the visual acuity of the patient with the head still and the head moving. Vestibulo-ocular reflex imbalance means that visual acuity decreases in 2 lines of the Snellen card when the head is moving. The DVA depends on the patient's adaptive response to pathology, thus the degree of VOR impairment may vary between patients with similar pathology. It should be emphasized that there is also a good correlation between the objective results of DVA and the subjective complaint of oscillopsia [7]. Oscillopsia may be the sign of vestibular hyporeactivity and some central diseases as cerebellar dysfunction. Patients with cerebellar dysfunction rarely complain spontaneously about altered vision during motion but specific questioning may bring up this symptom and DVA test confirms blurred vision [8].

The aim of our study was to assess the usefulness of bedside examination for screening of vestibular and balance system in occupational medicine practice.

Study groups

Study group comprised 165 subjects (70 male and 95 female). All patients were referred to Audiology and Phoniatry Clinic by audiologists because of subchronic or chronic vertigo, dizziness, unbalance. However, 55 subjects from that group reported transient spells of vertigous symptoms in anamnesis only, thus they were presented as asymptomatic. The mean age of study group was 45 years (standard deviation (SD) = 15, range: 18–78 years). Three subjects who revealed positive Hallpike test result were included after repositioning maneuver, if symptoms were over and repeated test was negative.

Videonystagmography (VNG) caloric test was the basis to divide group into 2 categories: vestibular caloric positive (canal paresis > 19%) and caloric negative (canal paresis ≤ 19%) groups.

Caloric-negative group was divided into 2 subgroups depending on oculomotor test results. Those included saccades assessment (cut off: latency 310 ms, velocity 200°/s, precision of 75%), 0.3 Hz smooth pursuit (normal gain ≥ 0.7, morphology assessment) and optokinetic test of 20°/s using moving chequered not whole-field target (normal gain ≥ 0.5).

Finally, 3 groups of patients were investigated in the study:

– vestibular group of 43 caloric-positive subjects (mean age: 53±13 years),
– central group of 79 caloric-negative patients with oculomotor abnormalities (mean age: 48±14 years),
– VNG-normal group of 43 patients (mean age: 38±13 years).

MATERIAL AND METHODS

All subjects underwent audiological (otoscopy, hearing) tests and neuro-otological examination including history of disease, physical examination and videonystagmography (VNG) recordings.

Medical history

Patients were asked about such symptoms as feeling of vertigo (spinning outside or inside the head), sensation of floating, rocking, lightheadedness, unbalance and tendency to sudden falls. Migrainous and non-migrainous headaches were also recognized as important. The qualification of headaches was performed in agreement with International Headache Classification (ICHD-3, 2013).

Medical examination

The set of 5 tests was performed as following: gaze nystagmus assessment, Dynamic Visual Acuity (DOV) and Head Impulse Test (HIT), Romberg test with eyes opened/closed and Unterberger test.

Gaze nystagmus

Eye movements have been noticed in direct observation (no Frenzel goggles were used), when patient was instructed to fixate vision on physician's finger and follow it moving 20° to the right and then to the left from central. Repeatable, horizontal nystagmus in left or right eye position was qualified as gaze nystagmus.

Head Impulse Test (HIT, Head-Trust or Halmagyi test)

Patients head has been pitched 30° down to move the subject's head in the plane of the lateral semicircular canals. Patient was asked to fixate on the top of the examiner's nose and the examiner moved the head quite rapidly to the left. Then the head was moved rapidly to the right. In healthy subject, eyes remained fixed on their target. Then the maneuver was repeated to the right side. If any labyrinth did not work properly, the eyes performed a catch-up saccades to the right or left to fixate the target again. This saccade showed the positivity of the test. Test was usually repeated 2 times.

Dynamic Visual Acuity Test (DVA)

This test can be administered using a traditional Snellen Chart used by ophthalmologists to measure visual acuity. At first, the smallest row that can be read accurately has been established (the baseline visual acuity). Then the physician, whilst standing behind the patient, began oscillating subject's head at about 1–2 Hz and measured visual acuity during head movement. Loss of one line is considered normal, whereas loss of 2–3 lines suggests vestibulo-oculomotor (VOR) weakness.

Romberg test

Patient was asked to stand with feet put close together and arm hung down along the body. The body movements were registered when patient kept the eyes open and then with eyes closed. Because in chronic balance disorders the true positive result (fall) was very uncommon, positive result was recognized when patient's body was markedly moving in any direction (side to side or front to back). The trial with eyes closed was more important.

Stepping Test

The qualitative Unterberger test was used in the study. No caloric stimulation was used before the test. Patient was asked to step in place at a normal walking speed during several minutes or until the forward movement occurs. If the angle of rotation was marked but less than 30°, the test was repeated. To eliminate external stimuli, the test was performed in silent, dark room.

Every test was assessed separately as positive (pathological) or negative (normal). Besides, the "clinical assessment 0–1" was positive (pathological) when none or one test was positive; "clinical assessment > 1" was considered to be positive if at least 2 of 5 tests were positive.

STATISTICS

The percentage of abnormal results, for each group was calculated. Cut-off scores for assigning normal or abnormal results of VNG tests were taken from previous studies looking at normative scores for these tests. To analyze the possible relationships between the categorical variables in 3 groups, Kruskal-Wallis non-parametric ANOVA test was used. Chi^2 test was computed in order to explore a possible relationship between the categorical variables obtained in 2 groups, so the Chi^2 analysis was based on a 2 by 2 table. For this, Yates' correction for continuity was explored in order to correct for overestimate of the Chi^2 value when a 2 by 2 table was used. Each group was compared to the other i.e., vestibular to central, vestibular to normal, central to normal groups. Statistica 6 pl software was used for testing.

RESULTS

In total, 82% of vestibular patients and 73% of central patients reported vestibular symptoms. Moreover, 40% of subjects in VNG-normal group were also symptomatic, reporting mainly unbalance and dizziness. The statistically significant differences between 3 groups were observed for balance abnormalities, vertigo, dizziness and tinnitus. Migraines were slightly more common in central group, but differences between groups were not statistically significant (Table 1).

Balance abnormalities were most common in central group, the statistical differences were observed between central and VNG-normal groups only ($p = 0.0141$). Vertigo was significantly more common in vestibular group as compared to central group ($p = 0.0006$) and VNG-normal group ($p = 0.0028$). Dizziness was the most common symptom in central group as compared to caloric-positive ($p = 0.0485$) and VNG-normal ($p = 0.0255$) groups.

The frequency of pathological bedside test results were listed in Table 2. The significant differences between 3 groups were found for Unterberger, HTT, DVA and gaze nystagmus tests. The results of *post hoc* analysis of frequency of the positive test results while comparing

Table 1. Symptoms reported by patients in study groups[a]

Symptom	Vestibular group (N = 43) [n (%)]	Central group (N = 79) [n (%)]	VNG-normal (N = 43) [n (%)]	p
Any recent vestibular/ balance symptom	35 (82)	58 (73)	17 (40)	0.0000*
Balance abnormalities	21 (48)	41 (52)	12 (28)	0.03250*
Vertigo	21 (48)	14 (18)	7 (16)	0.0002*
Dizziness	11 (26)	36 (46)	10 (23)	0.0160*
Oscillopsy	8 (19)	9 (11)	3 (7)	0.2460
Migraine headache	8 (19)	15 (19)	5 (12)	0.5541
Non-migrainous headache	8 (19)	21 (27)	4 (9)	0.0640

[a] The statistically significant differences between groups were for * $p < 0.05$.
VNG – videonystagmography.

separately every single group with another (Chi^2 test) are presented in Table 3. The statistically significant differences between vestibular and VNG-normal groups were noticed for all tests. The differences between vestibular and central groups were observed for Unterberger, HIT and DVA tests. There were no differences between central and VNG-normal groups for any single test, but clinical assessment revealed statistical difference.

In clinical assessment, sensitivity of tests set for vestibular pathology was 88% in comparison to caloric test results, specificity was 78%. Moreover, 79 (44%) of 122 caloric-negative patients revealed central abnormalities. Sensitivity of tests for central pathology was 68% as compared to VNG oculomotor tests. The agreement between symptoms and clinical examination results in central group was low, only 51% of clinically positive subjects had any

Table 2. The frequency of abnormal test results in study groups and the relationships between categorical variables in 3 groups (Kruskal-Wallis non-parametric ANOVA test)

Test	Vestibular group (N = 43) [n (%)]	Central group (N = 79) [n (%)]	VNG-normal (N = 43) [n (%)]	p
Romberg positive	11 (26)	19 (24)	7 (16)	0.5221
Unterberger positive	27 (63)	27 (34)	11 (26)	0.0008*
Head Impulse Test positive	19 (44)	15 (19)	3 (7)	0.0001*
Gaze nystagmus	15 (35)	19 (24)	5 (12)	0.0333*
DVA	27 (64)	24 (30)	7 (17)	0.0000*
In summary				
clinical assessment (0–1)[1]	38 (88)	54 (68)	18 (42)	0.0000*
clinical assessment > 1 test[2]	28 (65)	31 (39)	9 (21)	0.0002*

[1] Clinical assessment is classified as abnormal, if all tests are positive (abnormal).
[2] Clinical assessment is classified as abnormal if at least 4 of the 5 tests are abnormal.
DVA – Dynamic Visual Acuity; VNG – videonystagmography.
* $p < 0.05$.

Table 3. The results of *post hoc* comparisons of each group with one another (Chi² test)[a]

Test	Vestibular vs. central groups	Vestibular vs. VNG-normal groups	Central vs. VNG-normal groups
Unterberger positive	0.0011*	0.0011*	0.4384
Head Impulse Test positive	0.0059*	0.0002*	0.1286
Gaze nystagmus	0.2875	0.0216*	0.4931
DVA	0.0011*	0.0000*	0.1359
Clinical assessment (0–1)	0.0081*	0.0000*	0.0256*
Clinical assessment > 1 test	0.0011*	0.0001*	0.0634

[a] The frequency of abnormal tests results in study groups has been listed in Table 2. Romberg test was excluded from analysis because test results had not reached the statistical significance.
DVA, VNG – as in Table 2.
* Statistically significant at $p < 0.05$.

symptoms ($p = 0.6339$). In VNG-normal group, 13 of 18 symptomatic subjects (73%) had abnormal tests in clinical assessment. Symptoms and abnormal clinical assessment are significantly correlated ($p = 0.0007$) in that group.

DISCUSSION

A detailed symptoms collection is very useful for neuro-otological diagnosis. Patients recruited to the study were referred to Audiology and Phoniatry Clinic because of vertigo, dizziness and unbalance. Nystagmography recording is a reliable quantitative method to assess vestibulo-ocular reflex and eye tracking system [9,10]. In our study, VNG test results were the criterion of patient's classification. Although vestibular and balance symptoms were noticed in 82% of caloric-positive patients and in 73% of central subjects, also 40% of VNG-normal patients revealed vestibular and balance symptoms. Those data may confirm that routine VNG examination is not sufficient to diagnose balance system for occupational medicine. Moreover, in every day practice, caloric test is conclusive, while the central findings and balance tests (e.g., posturography) are of minor significance in the assessment of subject's ability to perform a job.

In medical examination we focused on 2 tests for postural examination and 3 oculomotor tests, preceded by The Dix-Hallpike Test to identify possible Benign Paroxysmal Positional Vertigo (BPPV). In our study, only 3 subjects revealed signs of benign paroxysmal positional vertigo, which resolved after repositioning maneuvers. Additionally, 2 of them presented some central abnormalities in VNG. In BPPV patients, the positioning vertigo and typical nystagmus usually disappear after repositioning maneuver, but residual dizziness and postural instability measured by posturography may continue even up to days [11] or event months [12] even if the tendency to falls disappears [12]. Being aware that successful treatment may not stop dizziness or further balance problems, we did not exclude BPPV patients from the study, similarly as we did not exclude migraine patients, who may develop dizziness, vertigo spells and postural and VNG abnormalities [13].

From tests used to examine the problem of spinal tract, we chose the Romberg test with eyes open/closed and Unterberger tests as the most popular and recommended by legal requirements. Tests for VOR assessment were as follows: spontaneous and gaze nystagmus assessment, Dynamic Visual Acuity Test (DVA) and Head Impulse Test (HIT).

Abnormal Romberg test results were similarly frequent in 3 study groups. Mostly, patients swayed in sagittal or frontal planes, which is usually a sign of proprioceptive or cerebellar lesions. More sway with eyes closed suggests

vestibular or proprioceptive lesions. None of our patients revealed lateralization characteristic for vestibular involvement. Similarly, in Cohen study [14] patients with benign paroxysmal positional vertigo, postoperative acoustic neuroma resection and chronic peripheral unilateral weakness did not differ significantly from healthy controls in test with eyes open or with eyes closed while on the floor. Only using this test with eyes closed on foam or in head movement conditions they revealed significantly reduced lateral balance control in study groups as compared to control one [14].

Some data suggest that Stepping Test was determined as unreliable for peripheral vestibular asymmetry screening as compared to caloric test [2,3]. In Honaker et al. study [15] increased abnormalities were observed only for dizzy patients with severe canal paresis (canal paresis 76–100%). These studies concerned quantitative Fukuda test, while we used the qualitative assessment. In our study, Unterberger test was positive in 63% of vestibular patients and this value was statistically different from central and normal groups. This value is even higher than in Honaker and Shepard study. They assessed the sensitivity of Fukuda test as 50% and specificity as 61% [3]. In that study, subjects with chronic disorder were included and the patient's level of compensation was not defined.

The importance of gaze-evoked nystagmus in chronic peripheral disease is rather low although in our study the prevalence of gaze nystagmus was correlated to vestibular imbalance confirmed by VNG-caloric test. Gaze-evoked nystagmus often is encountered in healthy patients; in which case it is called end-point nystagmus. End-point nystagmus does not appear within a small angle of gaze which was used in our examination.

Head Impulse Test (Head Thrust Test) is very useful for detecting an imbalance in a labyrinth function. The specificity of the HIT for identifying vestibular hypofunction is 82% [6] up to 95–100% [16,17], but the sensitivity varies from 34% or 39% [16] to 71% [6]. The sensitivity in our study was 44% which is more adequate to Harvey's study results [17]. The specificity was high and reached 93%.

The Dynamic Visual Acuity Test (DVA) is used to measure the visual acuity as a sign of VOR imbalance. The DVA test is simple and sensitive enough to separate normal subjects from patients suffering from a vestibular areflexia [7]. In Roberts and Gans study [18] both the vestibular and non-vestibular dizzy patients exhibited degradation in visual acuity, though not at all to the same extent. Sensitivity of the test for vestibular deficit assessment was 66.7% and specificity was 86.2%. In our investigation, sensitivity and specificity of DVA test was 64% and 83%, respectively; moreover, 1/4 of caloric-negative patients also revealed blurred vision during head movements.

The results of our study would not support the idea to use any single test from the test set as a reliable screening tool for peripheral vestibular asymmetry. It seems to be reasonable to use a combination of several clinical tests to get the most reliable vestibular assessment. In clinical practice the bedside examination is directed to separate central and vestibular vertigo and to find the test or test set strongly suggestive of canal paresis. In this context triple bedside test described by Rohmeier et al. [19] seems to present the high predictive value. The test battery including spontaneous nystagmus, head-shaking nystagmus, and the Head Impulse Test could predict a results on caloric testing with sensitivity of 63.6% and specificity of 85.4%.

Cnyrim et al. [20] in study devoted to distinguish vestibular neuritis and 'vestibular pseudoneurits' in acute disease found that only the set of tests including Head Impulse Test, saccadic pursuit, gaze evoked nystagmus and Subjective Visual Vertical revealed the sensitivity and specificity of 92%. Contrary to these findings, our test battery was designed to assess not only vestibular deficit, but central abnormalities and oscillopsia as well. In our study, clinical assessment (0–1 pathological test) revealed the results which were statistically different between groups compared one to the other. The specificity of test set was 58%

and the sensitivity for vestibular imbalance – 88%, to central abnormalities – 68%.

In agreement with this classification, 42% of VNG-normal patients showed positive (abnormal) clinical results and 73% of them reported vestibular and balance symptoms. Phobic vertigo or proprioceptive abnormalities may develop regardless of VNG results which may impair the ability of workers to perform some jobs.

CONCLUSIONS

The combination of 5 bedside tests are sufficiently sensitive to detect vestibular abnormalities.

Bedside examination abnormalities are highly correlated with vestibular/balance symptoms, regardless of the normal results of VNG. Thus, this method should be recommended for occupational medicine purposes.

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