Diagnostic Accuracy of HINTS Plus Test in the Differential Diagnosis of Central and Peripheral Vertigo: A Prospective, Cross-Sectional Study

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Abstract

Background

We evaluated the diagnostic accuracy of the HINTS Plus tool in differentiating central vertigo from peripheral vertigo in the emergency department, using neuroimaging as the reference standard.

Methods

This cross-sectional study included adult patients with acute vestibular syndrome without focal neurological deficits. Crucially, all patients underwent neuroimaging with non-contrast brain tomography and magnetic resonance imaging to definitively exclude central pathology. Diagnostic accuracy of the HINTS Plus test was assessed by comparing bedside findings with neuroimaging results.

Results

Of 298 patients enrolled, 62 had central and 236 peripheral vertigo patients. The sensitivity and specificity of the HINTS Plus for detecting central vertigo were 80.65% (95% CI: 68.63–89.58) and 82.63% (95% CI: 77.18–87.24), respectively. The Head Impulse Test demonstrated the highest sensitivity (70.97%) among individual components.

Conclusion

In our study, HINTS Plus sensitivity was lower than reported in literature. Consequently, the test is not sufficiently reliable to rule out central vertigo in isolation. We concluded that neuroimaging remains the standard of care for acute vestibular syndrome, even when HINTS Plus suggests a peripheral etiology.

Introduction

Dizziness is one of the challenging complaints encountered in the emergency department in terms of both diagnosis and management. The difficulty patients face in accurately describing their symptoms, the potential inconsistency with physical examination findings, and the fact that dizziness can be a symptom of numerous conditions may lead to diagnostic errors or missed diagnoses (1, 2) Life-threatening conditions may be overlooked, and the diagnostic sensitivity of tests used to detect these conditions is often low (3). Vertigo is a specific subtype of dizziness and can be described as a false sensation of movement, typically a feeling of spinning, in the absence of actual motion relative to gravity (4). Symptoms of vertigo, dizziness, and lightheadedness account for approximately 3% of all emergency department visits (5). The prevalence of vertigo is estimated to be 28.9% in women and 16.7% in men, while the annual incidence is approximately 4% in women and 2.3% in men (6). The central nervous system integrates inputs from the visual, vestibular, and proprioceptive systems. Central vertigo arises

from the involvement of central structures responsible for this integration and results in dysfunction of mechanisms such as the vestibulo-ocular reflex. In contrast, peripheral vertigo originates from the peripheral components of the vestibular system.

The prevalence of dizziness increases with age, which is associated with a decline in visual acuity, proprioception, and vestibular input, as well as an increased accumulation of otoconia within the semicircular canals (7). The differential diagnosis of dizziness includes ischemic stroke, transient ischemic attack, and intracranial hemorrhages. Due to the need for imaging modalities with high sensitivity and specificity for differential diagnosis, computed tomography (CT) and magnetic resonance imaging (MRI) are frequently preferred (8). The HINTS Plus test, which includes the Head Impulse Test, nystagmus examination, skew deviation test, and hearing loss assessment, is a bedside clinical tool particularly useful in emergency departments for distinguishing between central and peripheral vertigo in patients presenting with dizziness and imbalance. This test is believed to facilitate rapid and accurate diagnosis, enabling timely identification of central pathologies that require urgent intervention (7).

In this study, we aim to evaluate the diagnostic accuracy of the HINTS Plus test in differential diagnosis of peripheral and central vertigo using imaging modalities such as CT and MRI as the reference standard.

Methods

Design and Settings: This prospective, cross-sectional, single-center study was conducted at Ankara Bilkent City Hospital Emergency Department, with about 600,000 annual visits. Patients presenting between July 1, 2023, and July 1, 2024, were included. The center is designated as a stroke center offering systemic fibrinolysis and interventional radiology for ischemic and hemorrhagic strokes.

Ethical Approval: Ethical approval was granted by Ankara Bilkent City Hospital Ethics Committee No. 1 (Approval No: E1/3740/2023, Date: 21.06.2023). The study adhered to the Declaration of Helsinki. Authors declare no conflicts of interest and received no funding.

Eligibility: Patients aged over 18, conscious, hemodynamically stable, able to cooperate for the HINTS Plus test, presenting to the emergency department with acute vestibular syndrome without any neurological deficits (such as speech disturbance, motor weakness, facial asymmetry, or sensory loss), and exhibiting spontaneous nystagmus were included. Exclusion criteria were refusal to participate, Glasgow Coma Scale score below 15, trauma-related emergency visits, pregnancy, sedative or analgesic drug influence, contraindications or refusal for MRI, history of syncope or loss of consciousness, dizziness lasting longer than 7 days, positional dizziness lasting less than 2 minutes, and history of head trauma within the last 3 months.

Emergency Department Workflow: Patients meeting inclusion criteria and without exclusion criteria were enrolled after obtaining informed consent. Upon emergency admission, vital signs (including blood pressure, pulse, respiratory rate, temperature, and oxygen saturation) were recorded. Routine

electrocardiograms were performed. Patient history, system review, physical examination, and treatments were conducted by three emergency medicine residents trained for the study. Standard patient care was provided. In addition to routine examinations and tests, the HINTS Plus test was applied to patients presenting with acute vestibular syndrome, no neurological motor deficits, and a preliminary vertigo diagnosis. To definitively exclude central pathologies, both non-contrast brain CT (General Electric Revolution Evo 128) and diffusion-weighted MRI (SIGNA™ Explorer Lift) were performed on all included patients. CT was obtained for non-traumatic hemorrhagic cerebrovascular diseases, and MRI was performed for ischemic stroke. Imaging results were documented. Diagnosis of stroke was made by an emergency medicine specialist. Patients who underwent both CT and MRI and had a HINTS Plus test result indicative of central vertigo were admitted to the neurology department for further evaluation and treatment. Patients refusing routine tests after the HINTS Plus were to be excluded; however, none withdrew.

HINTS Plus Test: The HINTS Plus test was performed exclusively by three senior research assistants, each with at least two years of experience and prior theoretical and practical training on the test maneuvers. These assistants worked in rotating shifts in the emergency department, administering the HINTS Plus test to enrolled patients and recording the results in case report forms. The test comprises four components: Head Impulse Test, nystagmus examination, skew deviation test, and simple hearing assessment. If all components indicated peripheral vertigo, the test result was classified as peripheral vertigo; if any component suggested central vertigo, the result was classified as central vertigo. The Head Impulse Test assessed the vestibulo-ocular reflex by rapidly rotating the patient's head approximately 20° to the right and left while the patient focused on a fixed target (e.g., the examiner's nose). In patients with peripheral pathology, corrective refixation movements following head rotation were observed and recorded. During the nystagmus examination, the presence and type of nystagmus were evaluated. Spontaneous or provoked bilateral direction-changing nystagmus was interpreted as central vertigo, whereas spontaneous or provoked unidirectional nystagmus was considered indicative of peripheral vertigo. The Skew Test assessed vertical ocular misalignment by occluding each eye individually with the examiner's hand or a card while the patient focused on an object, observing for corrective eye movements upon uncovering. Absence of movement was recorded as consistent with peripheral vertigo. For the "Plus" component (the hearing assessment) hearing loss was evaluated by finger snapping near the patient's ear. Newly onset hearing loss was recorded as suggestive of central vertigo.

Primary and Secondary Outcomes: The HINTS Plus test results were recorded dichotomously as either central or peripheral vertigo. Additionally, the HINTS test alone (excluding the hearing assessment) was also evaluated and recorded similarly. The four components of the HINTS Plus test were documented as separate variables for central and peripheral vertigo. The dichotomous data (central/peripheral vertigo) obtained from the index test (HINTS Plus) were compared against the reference standard (MRI/CT imaging) using a 2x2 contingency table. Diagnostic accuracy metrics for the HINTS Plus test were derived from this comparison and recorded as the primary outcome. Secondary outcomes included analyses of differences in demographic data, vital signs, and symptoms between central and peripheral

vertigo groups, as well as the diagnostic accuracy of the HINTS test and each of its four components separately, along with comparisons between the two groups.

Statistical Analysis: Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 20.0 (Armonk, NY: IBM Corp.). Initially, demographic data, vital signs, and symptom distributions were summarized. The Shapiro-Wilk test was used to assess the distribution of continuous variables. For normally distributed variables, group comparisons (central vs. peripheral vertigo) were conducted using the Independent Samples t-test; for non-normally distributed variables, the Mann-Whitney U test was applied. Categorical variable proportions were compared using Pearson's Chi-square test or Fisher's Exact test, as appropriate. Diagnostic accuracy of the HINTS Plus test was evaluated by calculating sensitivity, specificity, positive and negative predictive values, with corresponding 95% confidence intervals. A p-value of less than 0.05 was considered statistically significant. Sample size calculation was based on an expected 20% prevalence of central vertigo and 85% diagnostic sensitivity, with 95% confidence level, 80% power, and ±10% absolute margin of error. This yielded a minimum required sample size of 245 patients, including approximately 49 with central vertigo.

Funding Declaration: The authors declare that this study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Results

During the one-year study period, 5223 patients with a preliminary diagnosis of vertigo underwent initial evaluation, and 298 patients meeting the criteria were analyzed. Based on the application of reference imaging tests, 79.2% (n = 236) of patients were diagnosed with peripheral vertigo and 20.8% (n = 62) with central vertigo. (Figure 1).

A total of 56.7% (n = 169) of the patients were female, and the mean age was calculated as 51.88 ± 16.18 years (Table 1). Among the included patients, 58.7% (n = 175) presented with imbalance, 46.6% (n = 139) with nausea, 46.6% (n = 139) with vomiting, and 19.1% (n = 57) with headache. Demographic data were analyzed according to the diagnosis of central or peripheral vertigo. Statistically significant differences were found between the central and peripheral vertigo groups in terms of age, sex, history of hypertension, and previous cerebrovascular disease (Table 1). The mean age of patients diagnosed with central vertigo was significantly higher, at 57.97 ± 14.23 years. Systolic and diastolic blood pressures were significantly higher in the central vertigo group, while no significant differences were observed between the groups in terms of heart rate and oxygen saturation. The rate of imbalance symptoms was higher in the central vertigo group. There were no significant differences in the rates of nausea, vomiting, or headache between the groups (Table 1).

According to the reference imaging results, 20.8% (n = 62) of the patients were diagnosed with central vertigo, whereas 30.5% (n = 91) were evaluated as having central vertigo based on the HINTS Plus test. The Head Impulse Test alone indicated central vertigo in 24.8% (n = 74) of cases. At the initial examination, in accordance with the inclusion criteria, all 298 patients (100%) exhibited spontaneous

nystagmus. Specifically, 90.3% (n = 269) had horizontal nystagmus consistent with a peripheral etiology, whereas 9.7% (n = 29) had vertical or rotatory nystagmus interpreted in favor of central vertigo (Table 1). The Skew Test results suggested central vertigo in 13.4% of patients. Hearing loss was detected in 2.7% of cases.

Based on the 2×2 contingency table comparing the reference diagnosis with the HINTS Plus test, the primary diagnostic performance metrics were evaluated. The sensitivity of the HINTS Plus test for diagnosing central vertigo was 80.65% (95% confidence interval (CI): 68.63–89.58), and the specificity was 82.63% (95% CI: 77.18–87.24) (Table 2). Additional metrics included a positive likelihood ratio (LR+) of 4.64, negative likelihood ratio (LR–) of 0.23, positive predictive value (PPV) of 54.95%, and negative predictive value (NPV) of 94.2%. Although overall accuracy was calculated as 82.21%, sensitivity and specificity were prioritized as the primary indicators of diagnostic validity in this clinical context (Table 2). Among the individual components, the Head Impulse Test had the highest sensitivity (70.97%), while nystagmus and hearing loss showed the highest specificity (97.46% and 97.88%, respectively). When evaluated without the hearing component (HINTS test only), 29.2% of patients were identified as having central vertigo. The diagnostic performance of the HINTS test alone showed a sensitivity of 79.03% and a specificity of 83.9% (Table 2).

Notably, twelve patients were misclassified by the HINTS Plus test as having peripheral vertigo (false negatives) but were definitively diagnosed with central pathologies (ischemic or hemorrhagic stroke) based on reference imaging (Table 3). The presence of these false negatives highlights the limitations of bedside testing in isolation. All 12 of these patients required immediate hospitalization in either the neurology ward or the intensive care unit and were subsequently discharged after receiving appropriate medical treatment (Table 3). No mortality related to central vertigo was observed in any patient during the study period.

Table 1: Demographic and Clinical Characteristics of the Patients

Variables			Diagnosis		
			Peripheral	Central	p-value
Total- n (%)			236 (79.2)	62 (20.8)	-
Demographics and vital signs	Age (year)- mean±SD		50.28±16.31	57.97±14.23	<0.001*
	Gender- n (%)	Male	88 (68.21)	41 (31.79)	<0.001‡
		Female	148 (87.57)	21 (12.43)	
	Diabetes Mellitus- n (%)		36 (70.58)	15 (29.22)	0.096‡
	Hypertension- n (%)		57 (70.37)	24 (29.63)	0.022‡
	Chronic Obstructive Pulmonary Disease- n (%)		3 (60)	2 (40)	0.279§
	Cerebrovascular Disease- n (%)		5 (41.66)	7 (58.34)	0.004§
	Chronic Kidney Failure- n (%)		0 (0)	1 (100)	0.208§
	Chronic Heart Failure- n (%)		2 (66.66)	1 (33.34)	0.505§
	Malignancy		2 (66.66)	1 (33.34)	0.505§
	Systolic Blood Pressure (mmHg)- mean ± SD		135.69±20.72	146.52±22.71	0.001*
	Diastolic Blood Pressure (mmHg)- mean ± SD		76.92±13.47	81.84±15.04	0.001*
	Heart Rate (/min)- med (25-75%)		86 (78-95)	88 (78-95)	0.663†
	SpO2 (%)		99 (97-99)	99 (96-99)	0.905†
Symptoms	Lightheadedness- n (%)		123(70.28)	52(29.72)	<0.001‡
	Nausea- n (%)		107 (76.97)	32 (23.03)	0.378‡
	Vomiting- n (%)		107 (76.97)	32 (23.03)	0.378‡
	Headache- n (%)		43 (75.43)	14 (24.57)	0.437‡
HINTS-Plus components	Head impulse- n (%)	Peripheral	206 (91.96)	18 (8.04)	<0.001‡
		Central	30 (40.54)	44 (59.46)	

	Nystagmus- n (%)**	Peripheral	230 (85.5)	39 (14.5)	<0.001‡
		Central	6 (20.68)	23 (70.32)	
	Test of skew- n (%)	Peripheral	219 (84.88)	39 (15.12)	<0.001‡
		Central	17 (42.5)	23 (57.5)	
	Hearing loss- n (%)	Peripheral	231 (79.65)	59 (20.35)	0.370§
		Central	5 (62.5)	3 (37.5)	
HINTS Plus test		Peripheral	195 (94.2)	12 (5.8)	<0.001‡
		Central	41 (45.05)	50 (54.95)	
HINTS test		Peripheral	198 (93.83)	13 (6.17)	<0.001‡
		Central	38 (43.67)	49 (56.33)	

* Student T test

‡ Pearson Chi-Square test

§ Fisher's Exact test

† Mann Whitney U test

**Peripheral: Horizontal nystagmus. Central: Vertical or rotatory nystagmus.

Table 2: Diagnostic Performance Metrics of the HINTS and HINTS Plus Tests

Variables	Sensitivity (95% CI)	Specificity (95% CI)	+LR (95% CI)	-LR (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)
HINTS-Plus	80.65% (68.63-89.58)	82.63% (77.18-87.24)	4.64 (3.42-6.29)	0.23 (0.14-0.38)	54.95% (47.37-62.3)	94.2% (90.69-96.44)	82.21% (77.39-86.38)
Head impulse	70.97% (58.05-81.8)	87.29% (82.35-91.26)	5.58 (3.85-8.08)	0.33 (0.22-0.49)	59.46% (50.32-67.99)	91.96% (88.55-94.43)	83.89% (79.22-87.88)
Nystagmus	37.1% (25.16-50.31)	97.46% (94.55-99.06)	14.59 (6.21-34.27)	0.65 (0.54-0.79)	79.31% (62.01-90)	85.5% (82.95-87.73)	84.9% (80.32-88.77)
Test of skew	37.1% (25.16-50.31)	92.80% (88.72-95.75)	5.15 (2.94-9.03)	0.68 (0.56-0.83)	57.5% (43.57-70.34)	84.88% (82.22-87.21)	81.21% (76.3-85.48)
Hearing loss	4.84% (1.01-13.5)	97.88% (95.13-99.31)	2.28 (0.56-9.28)	0.97 (0.91-1.03)	37.5% (12.85-70.95)	79.66% (78.68-80.6)	78.52% (73.42-83.05)
HINTS	79.03% (66.82-88.34)	83.9% (78.58-88.35)	4.91 (3.57-6.75)	0.25 (0.15-0.41)	56.32% (48.4-63.93)	93.84% (90.35-96.12)	82.89% (78.12-86.98)

Table 3: Characteristics and Outcomes of False-Negative Patients

Age	Gender	Diagnosis	Unit/Outcome
59	Female	Ischemic Stroke	Ward Admission/Discharge
67	Female	Hemorrhagic Stroke	Intensive Care Unit Admission/Discharge
46	Male	Hemorrhagic Stroke	Ward Admission/Discharge
53	Male	Hemorrhagic Stroke	Ward Admission/Discharge
59	Male	Ischemic Stroke	Ward Admission/Discharge
62	Male	Ischemic Stroke	Ward Admission/Discharge
67	Female	Hemorrhagic Stroke	Intensive Care Unit Admission/Discharge
37	Female	Ischemic Stroke	Ward Admission/Discharge
78	Female	Ischemic Stroke	Ward Admission/Discharge
60	Male	Ischemic Stroke	Ward Admission/Discharge
43	Male	Ischemic Stroke	Ward Admission/Discharge
43	Female	Ischemic Stroke	Ward Admission/Discharge

Discussion

In this study, we evaluated the HINTS Plus test in patients presenting with Acute Vestibular Syndrome without neurological motor deficits, using neuroimaging methods as the reference standard. In line with current clinical recommendations, only patients with spontaneous nystagmus were enrolled to avoid the diagnostic confusion associated with testing asymptomatic patients. The sensitivity and specificity of the HINTS Plus test for the differential diagnosis of central vertigo were found to be 80.65% (95% CI: 68.63–89.58) and 82.63% (95% CI: 77.18–87.24), respectively. Based on these findings, it was concluded that the HINTS Plus test alone may not be sufficiently reliable to exclude central vertigo in a real-world emergency department setting.

Gottlieb et al., in a meta-analysis including three studies with 128 patients, reported a sensitivity of 93.6% and a specificity of 65.1% (9). The high sensitivity and low specificity reported in their study likely stem from significant variations in inclusion and exclusion criteria across the pooled data. The studies by Siepman, Choi, and Sankalia included in that meta-analysis were evaluated separately here. Siepman et al. reported a sensitivity of 72.7% and a very low specificity of 36.8% for the HINTS Plus test (10). While their small sample size (n=30) limits the precision of these metrics, we believe our study's larger cohort provides a more robust representation of diagnostic performance. Although they used standardized video head impulse testing, our results reflect the clinical reality of bedside examination. Choi et al. reported a sensitivity of 100% and specificity of 75% (11). However, their study included only 23 patients and was restricted to those receiving neurology consultations, which introduces significant selection bias. In contrast, our study provides higher generalizability by including a broader spectrum of Acute Vestibular Syndrome patients presenting to a high-volume emergency department. Sankalia et al. reported 100% sensitivity for the HINTS Plus test in 75 patients (12). In our study, a lower sensitivity but higher specificity was observed. Unlike our research, Sankalia et al. included patients with overt neurological signs such as dysphagia and dysarthria, which naturally elevates sensitivity but misses the target population of "isolated" vertigo where the clinical dilemma is greatest. By focusing exclusively on patients without focal deficits, our study offers a more targeted assessment for frontline clinicians.

Qiu et al., in a prospective study of 239 patients, reported a sensitivity of 89.8% for the HINTS test (13). While their specificity is similar to ours, their higher sensitivity may be due to methodological differences; they completed both the HINTS test and MRI within one week and included a three-month follow-up for definitive diagnosis, which likely identified delayed central pathologies. Additionally, the distribution of age and gender in their sample was remarkably similar to ours, further highlighting that discrepancies in sensitivity are often due to reference standard timing.

Newman-Toker et al. reported a HINTS Plus sensitivity of 99.2% and specificity of 97% in 190 patients (14). The rate of central vertigo in their study was 65.3%, significantly higher than in our cohort and the general literature. Their population was also older (median age 61). Crucially, the near-perfect sensitivity in their study may be attributed to the specialized expertise of neuro-ophthalmologists, whereas our

findings represent "real-world" results achieved by senior emergency residents in a high-pressure environment.

Carmona et al. reported 100% sensitivity for the HINTS test in 114 patients (15). Their central vertigo group was older and, notably, all patients exhibited truncal ataxia—a finding not present in our more subtle cases. Furthermore, while their data were collected retrospectively, we conducted prospective examinations at the time of presentation, which accounts for the variations in reported sensitivity and specificity values.

Newman-Toker et al., in another prospective study of 101 patients, reported 100% sensitivity and 96% specificity (16). Their cohort had a mean age of 62 and included patients with overt central nervous system signs like facial palsy. The inclusion of such high-risk patients and direct CNS signs explains their higher sensitivity compared to our more challenging "neurologically intact" population.

Limitations and Generalizability

Including patients without neurological deficits who present diagnostic challenges in vertigo differentiation is one of the strengths of our study. In patients with clear findings like dysarthria or motor weakness, neuroimaging is mandatory and straightforward. Therefore, we believe our population represents the appropriate focus for HINTS Plus testing. The prospective design and large sample size further strengthen our findings.

A significant limitation is the timing of the reference standard. Diffusion-weighted MRI is known to yield false-negative results for small posterior circulation strokes within the first 24–48 hours; as neuroimaging was performed at initial presentation, some early central pathologies might have been missed, potentially underestimating the test's true performance. Additionally, our single-center design may limit generalizability. While testing was performed by three senior physicians for standardization, the use of video head impulse testing (vHIT) could have reduced operator dependency. Finally, the hearing test relied on bedside finger-snapping rather than objective audiometry, which, while practical for bedside use, remains a subjective assessment.

Conclusion

We conclude that detailed imaging techniques should be employed for patients whose HINTS Plus test results indicate central vertigo. However, the moderate sensitivity observed suggests that this test alone may not be sufficiently reliable to exclude central causes in vertigo patients without focal neurological deficits. Clinicians must be aware that bedside tests are highly operator-dependent and should be interpreted alongside the patient’s overall clinical risk profile.

Declarations

Ethics approval and consent to participate: Ethical approval was obtained from the Ankara Bilkent City Hospital Ethics Committee No. 1 (Approval No: E1/3740/2023, Date: 21.06.2023). All participants provided informed consent.

Availability of data and materials: The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: AS and AC designed the study and performed the clinical examinations. OO, BBK, and HB collected and analyzed the data. AC and AS drafted the manuscript. All authors read and approved the final manuscript.

Data Availability

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

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Figures

Figure 1:Flowchart

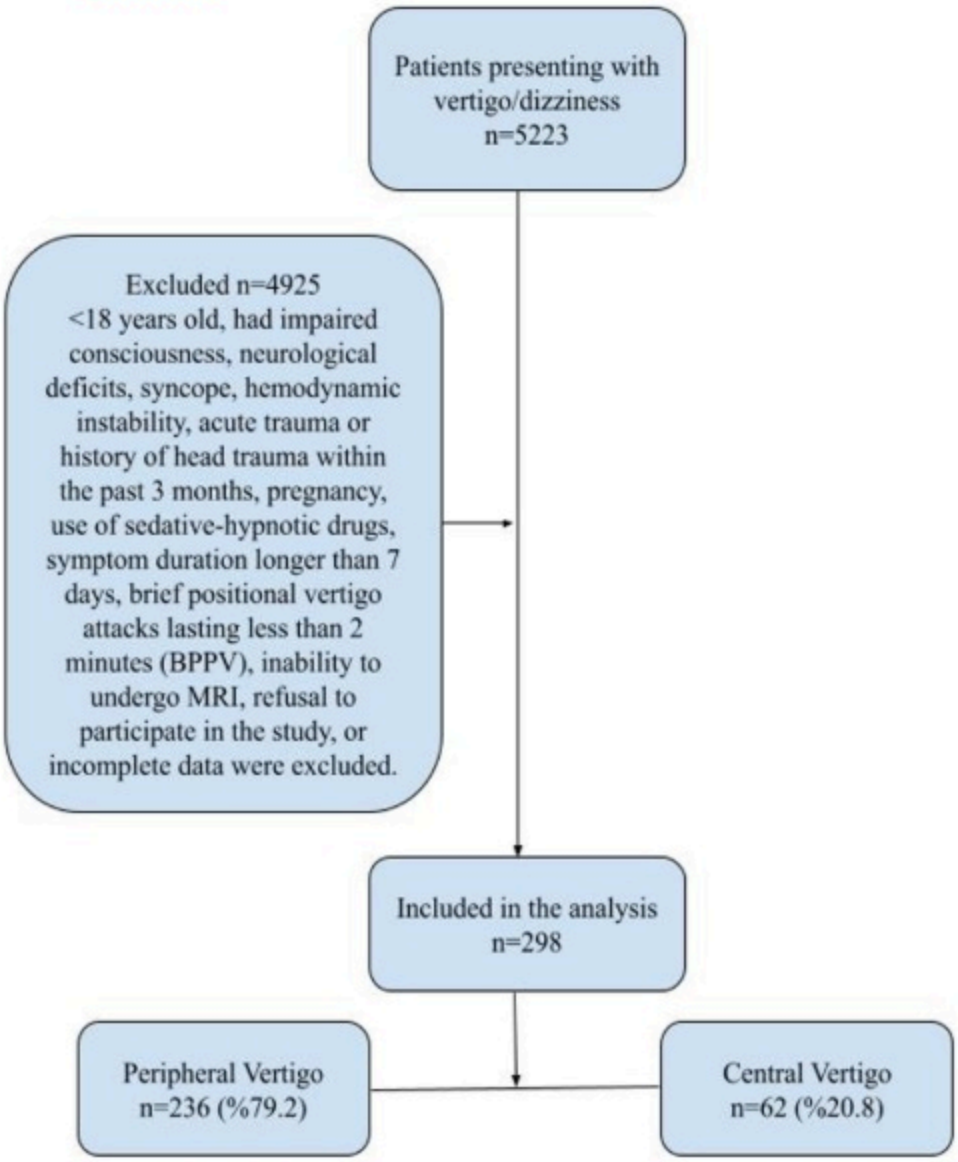

Figure 1

Flow chart

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