

RESEARCH PAPER

Vestibular vertigo and comorbid cognitive and psychiatric impairment: the 2008 National Health Interview Survey

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ABSTRACT

Background/aims Patients with vestibular disease have been observed to have concomitant cognitive and psychiatric dysfunction. We evaluated the association between vestibular vertigo, cognitive impairment and psychiatric conditions in a nationally representative sample of US adults.

Methods We performed a cross-sectional analysis using the 2008 National Health Interview Survey (NHIS), which included a Balance and Dizziness Supplement, and questions about cognitive function and psychiatric comorbidity. We evaluated the association between vestibular vertigo, cognitive impairment (memory loss, difficulty concentrating, confusion) and psychiatric diagnoses (depression, anxiety and panic disorder).

Results We observed an 8.4% 1-year prevalence of vestibular vertigo among US adults. In adjusted analyses, individuals with vestibular vertigo had an eightfold increased odds of 'serious difficulty concentrating or remembering' (OR 8.3, 95% CI 4.8 to 14.6) and a fourfold increased odds of activity limitation due to difficulty remembering or confusion (OR 3.9, 95% CI 3.1 to 5.0) relative to the rest of the US adults. Individuals with vestibular vertigo also had a threefold increased odds of depression (OR 3.4, 95% CI 2.9 to 3.9), anxiety (OR 3.2, 95% CI 2.8 to 3.6) and panic disorder (OR 3.4, 95% CI 2.9 to 4.0).

Conclusions Our findings indicate that vestibular impairment is associated with increased risk of cognitive and psychiatric comorbidity. The vestibular system is anatomically connected with widespread regions of the cerebral cortex, hippocampus and amygdala. Loss of vestibular inputs may lead to impairment of these cognitive and affective circuits. Further longitudinal research is required to determine if these associations are causal.

INTRODUCTION

Dizziness is a common symptom that affects 11–30% of the US population.^{1–5} A number of impairments can produce the phenotype of dizziness, including presyncope, low vision and vestibular loss.⁶ The population-based prevalence, specifically of vestibular vertigo, was previously estimated in the adult German population. Vestibular vertigo, defined as rotational vertigo, positional vertigo or recurrent dizziness with nausea and either oscillopsia or imbalance, was found to have a lifetime prevalence of 7.4%.⁷

Vestibular dysfunction is classically associated with a number of physical adverse outcomes, including postural instability and falls. A growing body of literature is demonstrating the broad range of cognitive impairments associated with vestibular dysfunction, including learning disability, and deficits in memory, executive function and visuospatial ability.^{8–16} Published accounts dating back to the first century also link vestibular disease to psychiatric symptoms, including panic disorder, anxiety and depression.^{6, 17–23} Moreover, some authors have provocatively hypothesised that vestibular loss may induce a negative affective response, which in turn may lead to cognitive impairment.^{24–26}

In this study, we analysed data from the 2008 National Health Interview Survey (NHIS) to estimate the prevalence of vestibular vertigo in US adults, and evaluate whether individuals with vestibular vertigo are more likely to have concomitant cognitive comorbidities (specifically memory loss and confusion) and psychiatric comorbidities (specifically depression, anxiety, panic disorder and psychological distress) relative to individuals without vestibular vertigo. Moreover, we used structural equation modelling to test the hypothesis that psychiatric disease may in part mediate the association between vestibular vertigo and cognitive impairment.

METHODS

The NHIS is an annual household interview survey conducted by the Census Bureau to track health status among the civilian, non-institutionalised US population. The survey is conducted using stratification, multistage sampling and a probability cluster sampling technique with over sampling of minorities to improve statistical estimates. With sponsorship from the National Institute on Deafness and Other Communication Disorders, National Institutes of Health, the 2008 NHIS was the first nationally representative survey to include a broad range of questions on balance and dizziness problems in the US adult population. The respondents were asked if, in the previous 12 months, they experienced any one of a number of dizziness or balance problems. Respondents with one or more balance problems were asked more detailed questions to assess the type and severity of their symptoms. Additionally, respondents were asked detailed questions about general health status, comorbidities and mental health. A total of 21 781 individuals aged 18 or older were interviewed in 2008, of whom 20 950

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(96.2%) completed the 2008 NHIS Balance and Dizziness Supplement.

Case definitions of vestibular vertigo

We used the same definition of vestibular vertigo developed in the German national survey described above.⁷ Vestibular vertigo was defined as rotational vertigo, positional vertigo or recurrent dizziness with nausea and either oscillopsia or imbalance. Neuhauser and colleagues validated this definition of vestibular vertigo by surveying 61 consecutive patients prior to their visit to a specialised dizziness clinic where they were interviewed and examined by a neurologist. They found the survey questions had a sensitivity of 84% and a specificity of 94% for identifying vestibular vertigo.⁷ In the NHIS, vertigo was defined as “an illusion of rotation or other motion, as if riding a ‘carousel’.” Rotational vertigo was ascertained with the question ‘In the past 12 months did you feel spinning or vertigo, a rocking of yourself or your surroundings?’. Positional vertigo was ascertained based on a positive response to any of the questions ‘Do any of the following trigger or cause your balance problem—looking up or down, turning your head side to side, rolling over in bed?’. Recurrent dizziness with nausea was defined as having nausea or vomiting around the same time as the balance problem. Oscillopsia and imbalance were defined as, ‘blurring of your vision when you move your head’ and ‘feeling off balance or unsteady’, respectively. When answering these questions, respondents were asked to not include times when they were drinking alcohol.

Other participant characteristics

Demographic data including age, sex, racial/ethnic background (including white, African-American, American-Indian, Asian, mixed race and Hispanic), education (stratified into less than high school, high school or equivalent and more than high school) and income (stratified into yearly family income <\$50k, \$50k–\$100k and >\$100k) were collected in NHIS and included in analyses. Cardiovascular risk factors were assessed with the question ‘have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure, or that you have diabetes or sugar diabetes?’. Smoking history was ascertained with the question ‘Have you ever smoked 100 cigarettes during your entire life?’. Visual loss was defined based on the question ‘do you have trouble seeing, even when wearing glasses or contact lenses?’, and hearing was assessed on a scale from 1–6 based on the question ‘without the use of hearing aids or other listening devices, is your hearing excellent, good, do you have a little trouble hearing, moderate trouble, a lot of trouble, or are you deaf?’.

Outcome measures

Questions regarding memory, depression, anxiety and panic disorder, were asked of all participants who completed the Balance and Dizziness Supplement. Difficulty remembering and confusion were defined based on the question ‘Are you limited in any way because of difficulty remembering or because you experience periods of confusion?’. Beginning in October of 2008, participants were asked a series of questions on disability, which included the question ‘Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?’. Since this question was added to the NHIS battery late in 2008, data are only available for 1630 respondents (compared to 20 950 for other questions).

Depression, anxiety and panic disorder were assessed with the questions ‘Have you ever had depression?’ ‘Have you ever

had generalised anxiety?’ and ‘Have you ever had panic disorder?’. Symptoms of psychological distress were assessed using the six-item Kessler Scale.²⁷ The scale consisted of the question ‘In the past 30 days, how often did you feel (1) so sad that nothing could cheer you up, (2) nervous, (3) restless or fidgety, (4) hopeless, (5) worthless, (6) that everything was an effort?’. These were scored on a five-point Likert scale, asking if participants experienced the symptom ‘none of the time, a little of the time, some of the time, most of the time, or all of the time’. The overall Kessler 6 score was calculated as the sum of the Likert scores of the six questions (range 0–24), and represented a composite measure of psychological distress. Responses to each item were also dichotomised, with a positive response defined as feeling the symptom most or all of the time.

Statistical analysis

Analyses were adjusted for the survey sampling design per NHIS guidelines to provide estimates that are representative of the general US adult population and with appropriate variance estimates. Multiple logistic regression and multiple linear regression were performed to evaluate for associations between vestibular vertigo, and continuous and categorical outcome measures, respectively, adjusting for demographic characteristics, cardiovascular risk factors, vision and hearing. We used structural equation models to evaluate whether psychiatric comorbidities mediated the association between vestibular vertigo, and memory loss, and confusion. All analyses were performed using STATA V13.

RESULTS

In the 2008 NHIS data, we observed that in the past year, 8.4% of US adults (approximately 18 million people) experienced vestibular vertigo (table 1). Women were significantly more likely than men to experience vestibular vertigo (10.7% vs 5.9%, $p<0.0001$), and the prevalence of vestibular vertigo increased with age from 5.7% in participants of 18–29 years to 10.9% among adults 70 years or older ($p<0.0001$). The prevalence of vestibular vertigo was significantly different between race and ethnicity groups, from a low of 4.4% in Asians to a high of 17.4% in mixed race individuals ($p<0.0001$). Vestibular vertigo decreased with increasing levels of education, from 10.6% among individuals with less than a high school education to 7.6% in individuals with a greater than high school education ($p=0.0001$). Vestibular vertigo was significantly more prevalent among individuals coming from families earning less than \$50 000 per year (10.8%) compared with those in higher family income groups (6.4–6.6%, $p<0.0001$). Individuals with a positive smoking history were significantly more likely to have vestibular vertigo compared with individuals who reported no smoking history (10.5% vs 6.8%, $p<0.0001$). Hypertension was also significantly associated with vestibular vertigo, with 12.4% of people with hypertension reporting vestibular vertigo compared with 6.7% among people without a history of hypertension ($p<0.0001$). Similarly, diabetes was significantly associated with vestibular vertigo, with 15.4% of patients with diabetes reporting vertigo, compared with 7.6% in individuals without diabetes ($p<0.0001$, table 1).

We next evaluated the association between vestibular vertigo and cognitive and psychiatric comorbidities (table 2). Twelve per cent of individuals with vestibular vertigo reported their activities were limited due to difficulty remembering or confusion, relative to 3.1% of all adults. This represented a 3.9-fold (OR 3.92, 95% CI 3.10 to 4.96, $p<0.001$) increase in the odds of activity limitation due to difficulty remembering or confusion among individuals with vestibular vertigo relative to the adult

Table 1 Demographic characteristics of individuals with vestibular vertigo from the NHIS 2008

US adult population	All respondents		Vestibular vertigo		
	Per cent	217 million (95% CI)	8.4% Per cent	(7.9% to 8.8%)* (95% CI)	18 million p Value†
Gender					
Male	48	(47.4 to 49.2)	5.9	(5.4 to 6.5)	<0.0001
Female	52	(50.8 to 52.6)	10.7	(10 to 11.4)	
Age (years)					
18–29	22	(21.3 to 23.2)	5.7	(4.8 to 6.7)	<0.0001
30–39	17	(16.7 to 18.1)	7.2	(6.2 to 8.3)	
40–49	19	(18.7 to 20.1)	8.9	(7.9 to 10.1)	
50–59	18	(17 to 18.3)	9.1	(8.0 to 10.4)	
60–69	12	(11.3 to 12.4)	10.5	(9.3 to 11.8)	
70+	12	(10.9 to 12.1)	10.9	(9.7 to 12.2)	
Race/ethnicity					
White	81	(80.3 to 82)	8.7	(8.2 to 9.3)	<0.0001
African–American	12	(11.1 to 12.6)	6.7	(5.8 to 7.7)	
American–Indian	1	(0.7 to 1.3)	6.7	(3.9 to 11.4)	
Asian	5	(4.3 to 5)	4.4	(3.2 to 6.0)	
Mixed race	1	(1.1 to 1.5)	17.4	(12.3 to 24.0)	
Hispanic	14	(12.9 to 14.4)	7.9	(6.8 to 9.2)	
Education					
<High school	15	(14.7 to 16.2)	10.6	(9.3 to 12.0)	0.0001
High school or GED	28	(26.8 to 28.6)	8.8	(7.9 to 9.7)	
>High school	57	(55.9 to 57.9)	7.6	(7.0 to 8.2)	
Income					
<\$50k	47	(46.1 to 48.4)	10.8	(10.1 to 11.6)	<0.0001
\$50k–\$100k	32	(31.3 to 33.1)	6.4	(5.7 to 7.1)	
>\$100k	21	(19.6–21.5)	6.6	(5.7 to 7.6)	
Smoking					
<100 lifetime cigarettes	58	(56.8 to 58.6)	6.8	(6.3 to 7.3)	<0.0001
≥100 lifetime cigarettes	42	(41.4 to 43.2)	10.5	(9.8 to 11.3)	
Hypertension					
No	71	(69.7 to 71.3)	6.7	(6.2 to 7.2)	<0.0001
Yes	30	(28.7 to 30.3)	12.4	(11.4 to 13.3)	
Diabetic					
No	92	(91.2 to 92.1)	7.6	(7.2 to 8.1)	<0.0001
Yes	8	(7.9 to 8.8)	15.4	(13.6 to 17.5)	

*95% CI.

† χ^2 Test.

GED, General Educational Development; NHIS, National Health Interview Survey.

population in adjusted analyses. In a subsample of 1630 participants who were asked additional questions, 25% of individuals with vestibular vertigo reported 'serious difficulty concentrating, remembering, or making decisions' relative to 4.9% in the adult population in the smaller sample. In multiple logistic regression analyses, individuals with vestibular vertigo had an 8.3-fold increase in the odds of serious difficulty among individuals with vestibular vertigo compared with the general adult population (OR 8.33, 95% CI 4.76 to 14.56, $p < 0.001$).

Sixty-two per cent of individuals with vestibular vertigo reported that they had ever been depressed, compared with 28% of adults in the US population. In adjusted analyses, individuals with vestibular vertigo had 3.4-fold increased odds of ever being depressed (OR 3.37, 95% CI 2.94 to 3.87, $p < 0.001$). A history of generalised anxiety disorder was present in 46% of individuals with vestibular vertigo compared with 19% of all adults. In adjusted analyses, individuals with vestibular vertigo had 3.2-fold increased odds of having a history of anxiety (OR 3.18, 95% CI 2.78 to 3.64, $p < 0.001$). A history of panic disorder was present in 26% of adults with vestibular vertigo

compared with 8% among all adults. In adjusted analyses, individuals with vestibular vertigo had 3.4-fold increased odds of having a panic disorder (OR 3.42, 95% CI 2.90 to 4.03, $p < 0.001$). Individuals with vestibular vertigo were more likely than the general adult population to feel worthless, hopeless, restless, nervous, sad or that everything was an effort most or all of the time. In the Kessler 6 psychological distress score, the mean score was 6 for people with vestibular vertigo, indicating moderate psychological distress, compared with a score of 2.4 for the general adult population, indicating no distress. Adjusted multiple linear regression analysis indicated that vestibular vertigo increased the Kessler 6 overall psychological distress score by 3.1 points on a scale of 0 to 24 (95% CI 2.72 to 3.39, $p < 0.001$; [table 2](#)).

We used structural equation models to assess whether psychiatric comorbidities mediated the association between vestibular vertigo, and memory loss, and confusion. In a combined model, the indirect effect of depression associated with vestibular vertigo on difficulty remembering or confusion was 13%; anxiety, 6.2%; and panic disorder, 13%. Combined, depression,

Table 2 Multiple logistic regression models of cognitive and psychiatric outcomes, and vestibular vertigo, from the 2008 National Health Interview Survey

	Prevalence				Logistic regression*	
	US adults		Vestibular vertigo		Vestibular vertigo	
	Per cent	(95% CI)	Per cent	(95% CI)	OR†	(95% CI)
Cognitive state						
Activities limited by difficulty remembering or confusion	3.1	(2.8 to 3.4)	12.2	(10.6 to 14.0)	3.92	(3.10 to 4.96)
Serious difficulty concentrating or remembering‡	4.9	(3.8 to 6.3)	24.8	(17.3 to 34.3)	8.33	(4.76 to 14.56)
Self-reported psychiatric condition						
Depression	28.3	(27.5 to 29.2)	61.6	(58.8 to 64.3)	3.37	(2.94 to 3.87)
General anxiety disorder	19.3	(18.6 to 20.1)	46.2	(43.4 to 48.9)	3.18	(2.78 to 3.64)
Panic disorder	8.0	(7.5 to 8.5)	25.8	(23.6 to 28.1)	3.42	(2.90 to 4.03)
In past 30 days have you most or all of the time felt						
Worthless	1.8	(1.6 to 2.1)	8.1	(6.7 to 9.7)	4.12	(3.09 to 5.49)
Hopeless	2.2	(2.0 to 2.5)	9.2	(7.8 to 10.9)	3.68	(2.83 to 4.79)
Restless	5.8	(5.3 to 6.2)	19.6	(17.5 to 22.0)	3.58	(2.92 to 4.38)
Nervous	4.0	(3.7 to 4.3)	15.1	(13.2 to 17.3)	3.56	(2.89 to 4.39)
Everything is an effort	5.5	(5.1 to 5.9)	18.6	(16.5 to 20.9)	3.26	(2.67 to 3.97)
Sad	3.2	(2.9 to 3.5)	10.9	(9.4 to 12.6)	3.25	(2.61 to 4.04)
	Mean	(95% CI)	Mean	(95% CI)	B-coefficient	(95% CI)
Kessler psychological distress score (0–24)	2.4	(2.37 to 2.52)	6.0	(5.7 to 6.3)	3.06	(2.72 to 3.39)

% Indicates, % prevalence of the outcome in US adults and individuals with dizziness or vestibular vertigo.

*Weighted analyses, compared with adult population, adjusted for age, sex, race, education, income, vision, hearing, smoking, hypertension and diabetes.

†All p Values <0.001, compared with US adult population.

‡Question added in October of 2008, n=1630, representing 2.3 million individuals (compared with n =20 950, approximately 217 million in other analyses).

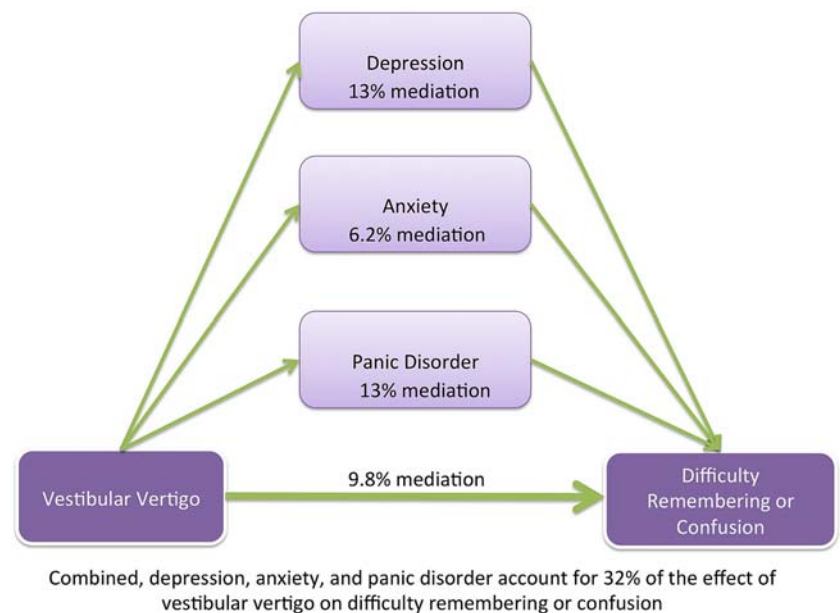
anxiety and panic disorder accounted for 32% of the effect of vestibular vertigo on difficulty remembering/confusion (figure 1).

DISCUSSION

We observed strong and consistent associations between vestibular vertigo, cognitive and psychiatric impairments in this large nationally representative survey of the US population. We found that difficulties with memory and confusion are significantly more common among individuals with vestibular vertigo relative to the general population. This finding confirms and extends the results of several small studies that suggested impairments in

memory and executive function associated with vestibular disease. A study of 33 patients with vestibular loss from gentamicin toxicity found that two-thirds of patients reported of cognitive impairment, ranging from memory loss to confusion to inability to prioritise tasks.¹² A report of 14 patients with vestibular vertigo documented that the patients had impairments in executive function, measured by the ability to count backward by two, and the digit span and arithmetic portions of the Wechsler Adult Intelligence Scale.¹¹ Recent studies have further characterised the cognitive impairments seen with vestibular disease in humans and in animals, and have highlighted the impairments in visuospatial ability seen with vestibular

Figure 1 Mediation analysis of vestibular vertigo, psychiatric comorbidity and cognitive impairment, National Health Interview Survey (NHIS) 2008.



loss.^{13 15 28–30} Visuospatial ability was not assessed in NHIS, although significant associations were nevertheless observed, in this large dataset, between vestibular vertigo and the cognitive domains of memory and attention.

Our results also show a strong association between vestibular vertigo and psychiatric diagnoses. A surprisingly high 62% of people with vestibular vertigo responded yes to the question 'Have you ever had depression?'. Additionally, 46% and 26% of people with vestibular vertigo reported having generalised anxiety and panic disorder, respectively. The adjusted multiple logistic regression models suggest that people with vestibular vertigo are more than three times as likely to have depression, anxiety, or panic disorder as compared with the general population. The mean Kessler 6 score of psychological distress for people with vestibular vertigo was 6 on a 0–24 scale. This placed them in the category of moderate mental distress (5–13), indicating that their mental distress likely had a functional impact and necessitated treatment.³¹ These results reinforce the importance of screening individuals with symptoms of vestibular vertigo for comorbid psychiatric conditions and making referral to mental healthcare as needed.

Our results demonstrate a high prevalence of comorbid vestibular vertigo and depression in the US adult population, and validate previously published work on smaller samples of patients with vertigo recruited from specialised dizziness centres. A study of 120 consecutively seen neurotology patients who were interviewed by a clinical psychologist found that 64% of the dizzy patients were in need of psychological help.³² A Portuguese study followed 60 patients with vertigo over a 2-year period and found that more than two-thirds (42 of 60) experienced at least one moderate depressive episode.³³ A recent study found that 49% of patients with vertigo or dizziness also met criteria for diagnosis of a psychiatric disorder.²² Another recent study found that affective control and mood were altered when vertigo was induced with caloric vestibular stimulation.²³ However, not all studies have observed such a high prevalence of comorbid depression with vertiginous disorders. Using the Hospital Anxiety and Depression Scale (HADS), one study from the UK found that 17% of dizzy and vertiginous patients were depressed, and 29% were anxious.³⁴ Another study conducted in Finland using the Beck Depression Inventory (BDI) found that 19% of patients with vertigo were depressed.³⁵ The population-based study in Germany, discussed previously, found a 17% prevalence of self-reported depression in the past year among individuals with vestibular vertigo. The difference in the prevalence of psychiatric conditions among individuals with vestibular vertigo in these studies may be due to differences in definitions of depression (HADS, BDI, K6, self-reported) or due to differences in the populations studied. The question used in the NHIS study 'Have you ever been depressed?', is quite broad and does not establish the timing of the depressive episode relative to vertigo symptoms.

There is a complex interaction between vertigo and psychological distress. In some individuals, vertigo may lead to psychological distress, while in others the reverse appears to be true, with psychological distress manifesting as vertigo or dizziness. Patients tend to avoid activities they associate with dizziness due to the unpleasant feeling of vertigo or anxiety about the potential for physical harm or social embarrassment. Unfortunately, this avoidance behaviour can actually worsen dizziness and psychological symptoms.^{20 24 25 36 37} The mechanism that links psychological distress and symptoms of dizziness or vertigo is still unclear, but several authors hypothesise it is related to the substantial overlap of neuroanatomical regions and

neurotransmitters involved in the vestibular system and pathways implicated in emotional states.^{21 38}

In our structural equation model mediation analysis, we found a significant relationship between vestibular vertigo, psychiatric comorbidity and difficulty remembering or confusion. Combined, vertigo-associated depression, anxiety and panic disorder accounted for 32% of the effect of vestibular vertigo on difficulty remembering. This suggests a substantial portion of the impaired cognitive function seen in vertigo is due to comorbid psychiatric disease. However, our model including psychiatric comorbidity did not account for nearly two-thirds of the effect of vestibular vertigo on cognitive function, suggesting other factors are at play, perhaps related to hippocampal atrophy, which was demonstrated in bilateral vestibular failure patients.³⁰

The strength and value of our analysis comes from the large scale of the NHIS data set, and the validated sampling and weighting methods that make the results generalisable to the US population. The 2008 NHIS Balance and Dizziness Supplement gathered extensive information about the symptoms and effects of dizziness, which included questions that had previously been validated to identify vestibular vertigo.⁷ Limitations of the study are that it was cross-sectional, thus prohibiting causal inferences. The study was also limited by the fact that it was completed using entirely self-reported outcomes without any objective measurements of vertigo, depression or cognitive function.

We found that individuals with vestibular vertigo were more than three times as likely as other adults to report a history of depression, general anxiety disorder and panic disorder. Additionally, individuals with vestibular vertigo were nearly four times as likely to report feeling their activities were limited by difficulty remembering or confusion, demonstrating the cognitive impact of the symptom of vertigo. These results underscore the high prevalence of vestibular vertigo, and the large amount of psychiatric and cognitive comorbidity in this population.

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