Dizziness, Vertigo & Falls in Persons with Diabetes

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National Healthcare Crisis

- Dizziness, vertigo, and falls were identified as early as 1994 in the NIH Strategic Research Plan as a looming national health care crisis for the United States.

- Based on the current prevalence of these complaints in the older adult population and the coming wave of post World War II (1946-1964) older adults and the social and economic impact.

- Diabetes now affects 9.3% of U.S. - over 29 million people

(CDC, 2014)

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Description:

This course will provide attendees with an overview of the affect of diabetes on the three primary sensory modalities of balance; vision-vestibular and somatosensory. A review of the literature will be presented to document the evidence-based research, which clearly demonstrates; the significant impact of the disease on individuals, corresponding vestibular-balance test results as well as intervention strategies.

Participants will be provided with clinical pathways, which may be incorporated into their practice to facilitate identification and intervention for individuals with diabetes, who are experiencing debilitating conditions and increased fall risk which can have life-altering implications.

Objectives: At the conclusion of the class, attendees will be able to…

1. List the changes that occur in each of the sensory modalities.
2. Name those vestibular-balance tests, which have greatest sensitivity to diabetic-related changes.
3. Describe best practices to implement identification and intervention protocols within a diabetic fall risk management program.

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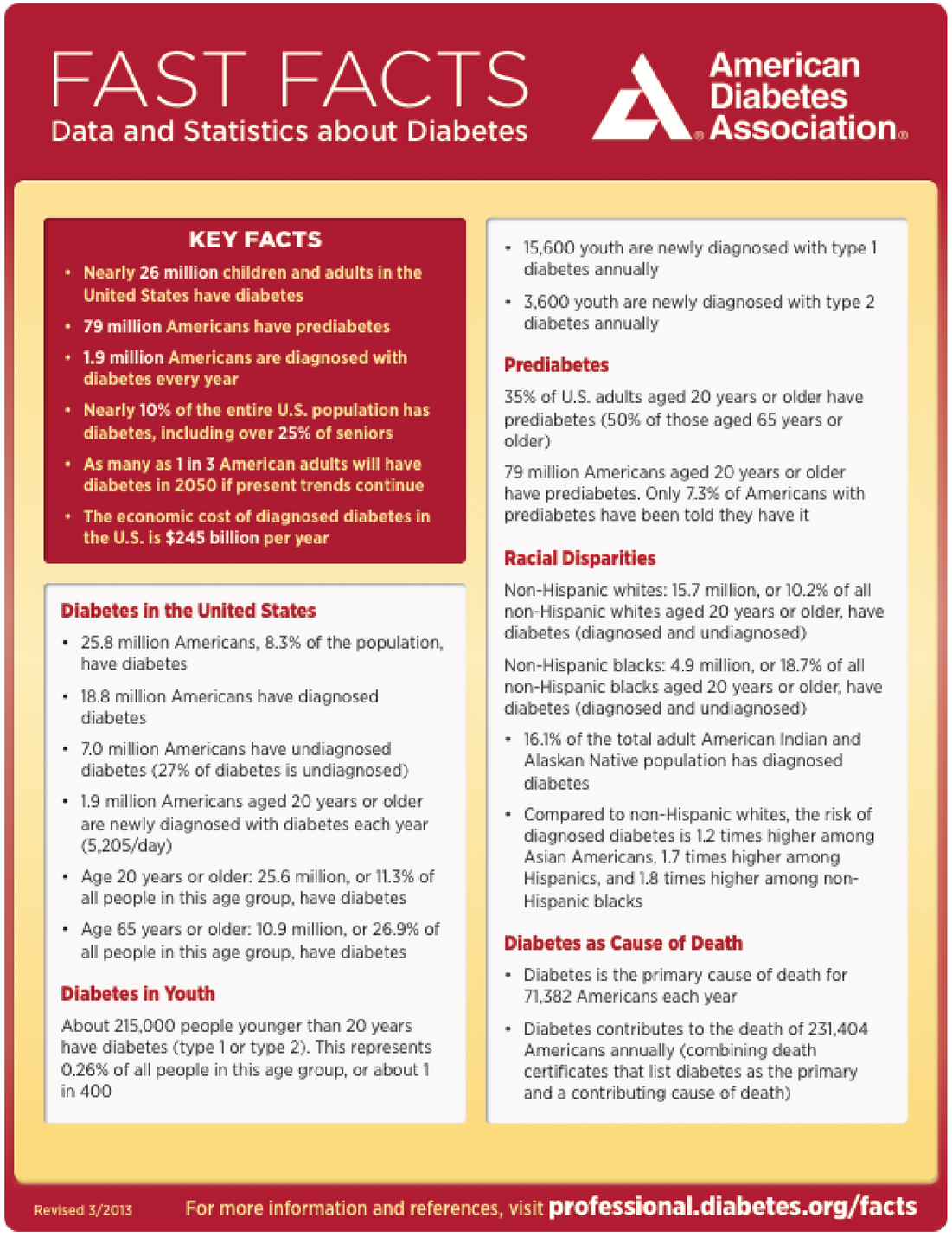

FAST FACTS

Data and Statistics about Diabetes

American Diabetes Association.

KEY FACTS

- **Nearly 26 million children and adults in the United States have diabetes**
- **79 million Americans have prediabetes**
- **1.9 million Americans are diagnosed with diabetes every year**
- **Nearly 10% of the entire U.S. population has diabetes, including over 25% of seniors**
- **As many as 1 in 3 American adults will have diabetes in 2050 if present trends continue**
- **The economic cost of diagnosed diabetes in the U.S. is $245 billion per year**

Diabetes in the United States

- 25.8 million Americans, 8.3% of the population, have diabetes
- 18.8 million Americans have diagnosed diabetes
- 7.0 million Americans have undiagnosed diabetes (27% of diabetes is undiagnosed)
- 1.9 million Americans aged 20 years or older are newly diagnosed with diabetes each year (5,205/day)
- Age 20 years or older: 25.6 million, or 11.3% of all people in this age group, have diabetes
- Age 65 years or older: 10.9 million, or 26.9% of all people in this age group, have diabetes

Diabetes in Youth

About 215,000 people younger than 20 years have diabetes (type 1 or type 2). This represents 0.26% of all people in this age group, or about 1 in 400

- 15,600 youth are newly diagnosed with type 1 diabetes annually
- 3,600 youth are newly diagnosed with type 2 diabetes annually

Prediabetes

35% of U.S. adults aged 20 years or older have prediabetes (50% of those aged 65 years or older)

79 million Americans aged 20 years or older have prediabetes. Only 7.3% of Americans with prediabetes have been told they have it

Racial Disparities

Non-Hispanic whites: 15.7 million, or 10.2% of all non-Hispanic whites aged 20 years or older, have diabetes (diagnosed and undiagnosed)

Non-Hispanic blacks: 4.9 million, or 18.7% of all non-Hispanic blacks aged 20 years or older, have diabetes (diagnosed and undiagnosed)

- 16.1% of the total adult American Indian and Alaskan Native population has diagnosed diabetes
- Compared to non-Hispanic whites, the risk of diagnosed diabetes is 1.2 times higher among Asian Americans, 1.7 times higher among Hispanics, and 1.8 times higher among non-Hispanic blacks

Diabetes as Cause of Death

- Diabetes is the primary cause of death for 71,382 Americans each year
- Diabetes contributes to the death of 231,404 Americans annually (combining death certificates that list diabetes as the primary and a contributing cause of death)

Revised 3/2013 For more information and references, visit **professional.diabetes.org/facts**

How Does this Affect Your Patients?

In 2005–2008, 4.2 million (28.5%) people with diabetes aged 40 years or older had diabetic retinopathy

Hearing loss is about twice as common in adults with diabetes as those who do not have diabetes

About 60% to 70% of people with diabetes have mild to severe forms of neuropathy

Greater incidence of BPPV

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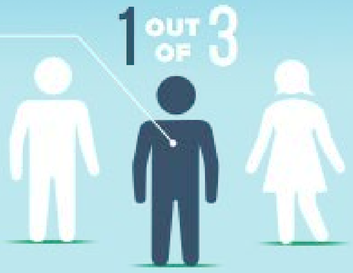
PREDIABETES

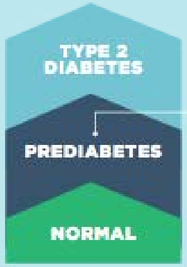
COULD IT BE YOU?

84.1 MILLION

84.1 million American adults — more than 1 out of 3 — have prediabetes



9 OUT OF 10 people with prediabetes don't know they have it



Prediabetes is when your blood sugar level is higher than normal but not high enough yet to be diagnosed as type 2 diabetes

Prediabetes increases your risk of:

If you have prediabetes, losing weight by:

can cut your risk of getting type 2 diabetes in

HALF

NATIONAL DIABETES INFORMATION CLEARINGHOUSE (NDIC)

Prediabetes

What You Need to Know

Did you know that if you are 45 years old or older, overweight, and inactive, you may have prediabetes?

What is prediabetes?

Prediabetes means the amount of glucose, also called sugar, in your blood is higher than normal but not high enough to be called diabetes. Glucose is a form of sugar your body uses for energy. Too much glucose in your blood can damage your body over time. If you have prediabetes, also called impaired fasting glucose (IFG) or impaired glucose tolerance (IGT), you are more likely to develop type 2 diabetes, heart disease, and stroke.

How do I know if I have prediabetes?

Most people with prediabetes don't have any symptoms. Your doctor can test your blood to find out if your blood glucose levels are higher than normal.

Who should be tested for prediabetes?

If you are 45 years old or older, your doctor may recommend that you be tested for prediabetes, especially if you are overweight. Being overweight is a key contributor, along with inactivity, to prediabetes. If your body mass index (BMI) is higher than 25, you are overweight. BMI is a measure of your weight relative to your height. If you're not sure if you are overweight, ask your doctor.

Even if you are younger than 45, consider getting tested for prediabetes if you are overweight and

- are physically inactive
- have a parent, brother, or sister with diabetes
- have high blood pressure or high cholesterol—blood fat
- have abnormal levels of HDL, or good, cholesterol or triglycerides—another type of blood fat
- had gestational diabetes—diabetes that develops only during pregnancy—or gave birth to a baby weighing more than 9 pounds
- are African American, Alaska Native, American Indian, Asian American, Hispanic/Latino, or Pacific Islander American
- have polycystic ovary syndrome, also called PCOS
- have a dark, velvety rash around your neck or armpits
- have blood vessel problems affecting your heart, brain, or legs

If your test results are normal, you should be retested in 3 years. If you have prediabetes, ask your doctor if you should be tested again in 1 year.

NIH
National Institute of Diabetes and Digestive and Kidney Diseases

Abstract

Dizziness, vertigo, and falls will affect over 35% of the U.S. population over 40 years of age. The scientific literature indicates a higher prevalence, as great as 70%, within the diabetic population. This demographic includes many older adults over the age of 70 who have a greater incidence of co-morbidities which places them at a further elevated fall risk.

This discussion will include a review of the literature of the relationship between diabetes and balance disorders. Evidence based suggestions for intervention strategies in the identification and management of this population will be included.

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Overview

- Scope of problem
- Relationship and implications of diabetes to dizziness, vertigo, and falls
- Intervention strategies for identification, treatment, and fall risk management

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Dizziness, Vertigo, Falls...

- Dizziness is the number one complaint of persons over age 70 years.
- 85% of vertigo and balance dysfunction may be inner ear related.
- 50% of individuals over age 70 years will experience Benign Paroxysmal Positioning Vertigo (BPPV).
- Older adults with BPPV have a greater incidence of depression, falls and reduced activities of daily living.

(Gans, 2011)

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Falls: Morbidity and Mortality

- Falls are the leading cause of traumatic brain injury (TBI) and bone fractures (femur, wrist, and hip).
- **Falls are the leading cause of accidental deaths in persons over age 65 years.**
- Falls are the 6th leading cause of death for the elderly.
- 60% of fall-related deaths occur among individuals who are 75 years of age or older.
- 20% of those who sustain a hip fracture from a fall will die within a year
- Of those who do fall, 20% will require placement within a long-term care facility.

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Business

U.S. Deaths From Falls Projected to Rise Due to Aging Baby Boomers

By Vincent Del Giudice
May 15, 2018, 1:38 PM EDT

- Ominous data from Centers for Disease Control and Prevention
- Data show sharp rise in fatal falls reported from 2007 to 2016

LISTEN TO ARTICLE
▶ :58

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Watch where you step because the autumn of our lives is forecast to become much more slippery.

Researchers project the number of deaths of older Americans resulting from falls across the U.S. will increase to 59,000 in 2030 from 30,000 in 2016 and 18,000 in 2007, according to data from the U.S. Centers for Disease Control and Prevention.

That equates to 162 deaths a day -- or almost seven deaths an hour -- by 2030.

Number of deaths	2007	2016
Total	18,334	29,668
Men	8,408	13,721
Women	9,926	15,947

The segment of the U.S. population at 85 years and older is forecast to increase to 8.9 million by 2030, with risk factors including reduced activity, chronic conditions such as arthritis, the impact of prescription medications on mobility and changes in gait and balance, according to the CDC. More than 95 percent of hip fractures are caused by falling.

In 2015, the total medical costs for falls surpassed $50 billion.

Equilibrium

Internal
Vestibular

External
- Visual
- Somatosensory

CNS
Sensory motor integration and appropriate motor response.

Individuals with Diabetes...

- Risk of falling is increased with diabetes
- Diabetics are 70% more likely to have vestibular dysfunction
- Individuals with other diabetic related conditions e.g. retinopathy, neuropathy, are more likely to have vestibular dysfunction
- Although retinopathy and neuropathy contribute to a cascade effect, vestibular dysfunction alone is a greater cause of falls

(Agrawal et al., 2010)

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Individuals with Diabetes...

- Increased prevalence of Benign Paroxysmal Positional Vertigo (BPPV) - which increases fall risk
- Reduced sensory input from inner ear -balance system, vision, lower extremities (neuropathy) cumulatively create a complex interaction of dysfunction " the perfect storm"
- Individuals 40 years of age and older with undiagnosed/untreated hearing loss have a higher incidence of falls

(Agrawal et al., 2010)

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Review of Studies Demonstrating Abnormal Findings

Study	Participants			Evidence of Vestibular Dysfunction
	Group	N	Age (y), $\bar{X}$ (SD)	
Biurrun et al[40]	Type 1 DM	46	25.9 (8.9)	21.8% of participants with DM had bilateral depressed caloric responses; oculomotor ENG tracings showed abnormal responses in 54.3% of participants with DM; abnormal responses were seen in participants with a longer duration of DM and with complications from retinopathy or nephropathy
	Control	33	26.2 (9.4)	
Gawron et al[9]	Type 1 DM	95	15.5 (5.1)	Impaired optokinetic responses and significant increases in spontaneous and positional nystagmus were seen in participants with severe hypoglycemic incidents, a longer duration of DM, and uncontrolled disease
	Control	44	16.3 (6.1)	
Nicholson et al[41]	Type 1 DM	18	62.7 (21.1)	Gaze holding in darkness was worse for participants with diabetes than for controls; VOR gains were similar in the groups; however, phase velocity was decreased in participants with type 1 diabetes; OKR slow-phase velocity was decreased in both groups with diabetes, and postural sway was increased in both groups with diabetes
	Type 2 DM	23	65.4 (10.5)	
	Control	45	60.9 (8.2)	
Cohen et al[47]	Unilateral posterior canal BPPV	176	57 (13)	The prevalence of DM in participants with BPPV was significant ($P<.001$); equilibrium scores on condition 5 of the SOT were significantly lower in participants with BPPV and DM than in those without DM

[a] DM=diabetes mellitus, ENG=electronystagmography, VOR=vestibular-ocular reflex, OKR=optokinetic reflex, BPPV=benign paroxysmal positional vertigo, SOT=Sensory Organization Test, DPN=diabetic peripheral neuropathy, VNG=videonystagmography.

(D'Silva et al., 2016)

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Study	Participants			Evidence of Vestibular Dysfunction
	Group	N	Age (y), $\overline{X}$ (SD)	
Klagenberg et al[39]	Type 1 DM	30	25.7	Caloric test abnormalities were seen in 60% of participants; 40% had hyporeflexia, and 20% had hyperreflexia; spontaneous nystagmus, positional nystagmus, and OKRs were within normal limits
Agrawal et al[7]	Adults >40 y old	5,086		The modified Romberg test of standing balance on firm and compliant support surfaces was used to determine vestibular dysfunction; the odds of vestibular dysfunction were 70% higher in people with diabetes; the risk of falls in people with vestibular dysfunction and complaints of dizziness was increased 12-fold
Kim et al[79]	Type 2 DM	35	51.1 (15.5)	19 participants with DPN and complaints of vertigo received vestibular testing, which included a clinical examination for spontaneous and gaze-evoked nystagmus, positional testing, VNG, and caloric tests; 11 participants (57.9%) had vestibular dysfunction, on the basis of abnormal caloric responses
Chavez-Delgado et al[42]	Type 2 DM, hypertension, and dyslipidemia	385	62 (12.9)	40% of the study population had complaints of dizziness and received vestibular testing; spontaneous nystagmus was seen in 2.8% of the population; abnormal caloric responses were seen unilaterally in 73.4% of the participants and bilaterally in 26.6% of the participants
De Stefano et al[80]	Diabetes, hypertension	1,092	72.9 (6.14)	The number of recurrences of BPPV was related to the number of comorbidities; the combination of hypertension, diabetes, osteoarthritis, and osteoporosis increased the risk of recurrence 6.48 times

[a] DM=diabetes mellitus, ENG=electronystagmography, VOR=vestibular-ocular reflex, OKR=optokinetic reflex, BPPV=benign paroxysmal positional vertigo, SOT=Sensory Organization Test, DPN=diabetic peripheral neuropathy, VNG=videonystagmography.

(D'Silva et al., 2016)

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Review of Intervention Studies

Table 2.
Summary of Balance Training Interventions in People With Type 2 Diabetes[a]

Study	N	Type of Exercise	Frequency	Duration	Outcome Measures for Balance and Falls	Results
Richardson et al[81]	20 (10 in IG, 10 in CG)	For IG: strength and balance exercises to improve ankle function; for CG: seated exercises	Daily	3 wk	SLS, FRT, tandem stance time, ABC Scale	For IG: significant improvements in single-leg and tandem stance and FRT scores; for CG: no change in all measures
Kruse et al[74]	79 (41 in IG, 38 in CG)	For IG: strengthening, balance, and walking program in part 1 and motivational phone calls in part 2; for CG: 8 sessions, diabetes care instruction, no exercises	Part 1: 8 individual sessions, 3 home visits (1 h each); part 2: motivational phone calls (every other week)	Part 1: 1–3 mo; part 2: 4–12 mo	Ankle dorsiflexor strength, BBS, TUG, SLS, FES	No difference between groups in any measures
Allet et al[75]	71 (35 in IG, 36 in CG)	For IG: gait, balance, and function-oriented strengthening; for CG: no treatment, no advice	2×/wk	12 wk	Walking speed, POMA, dynamic balance walking on a beam, static balance on the Biodex, FES-I	For IG: gait velocity increased 11.6%, dynamic balance improved by 34%, static balance improved by 31%, higher POMA and FES-I scores
Morrison et al[82]	37 (16 with T2D, 21 healthy controls)	Balance and resistance training	3×/wk	6 wk	Fall history, fall risk assessment (PPA)	Significant decrease in fall risk with improvements in proprioception and quadriceps and hamstring strength seen in people with T2D
Ahn and Song[83]	59 (30 in IG, 29 in CG)	Tai chi	1 h per session, 2×/wk	12 wk	SLS with eyes closed, SF-36	For IG: significant improvements in SLS and SF-36 scores
Salsabili et al[84]	19 with T2D	Biodex[b] stability system for training	10 sessions, 30 min each	3 wk	Overall Stability Index, APSI, MLSI on the Biodex	Decreased OSI, APSI, and MLSI scores with training in all participants
Song et al[85]	38 (19 in IG, 19 in CG)	Eyes open and eyes closed, on foam and on a trampoline	1 h, 2×/wk	8 wk	SLS with eyes open and eyes closed, BBS, FRT, TUG, 10-min walk, postural sway	For IG: significant increases in BBS, FRT, and 10-min walk scores; improvement in SLS time; decrease in postural sway
Morrison et al[86]	37 (21 without T2D, 16 with T2D)	Balance and strength training	3×/wk	6 wk	PPA, forceplate test in mCTSIB conditions	Significant decreases in fall risk in both groups; in the T2D group, decreased AP-ML coupling, higher range of COP motion, decreased COP velocity
Mueller et al[87]	29 (15 in WB, 14 in NWB)	For WB group: balance, strength, and progressive walking; for NWB group: strength and progressive stationary bike	1 h, 3×/wk	12 wk	6-min walk distance, daily step counts	For WB group: improvements in 6-min walk distance and average daily steps

[a] IG=intervention group, CG=control group, SLS=single-leg stance, FRT=Functional Reach Test, ABC=Activities-specific Balance Confidence, BBS=Berg Balance Scale, TUG=Timed "Up & Go" Test, FES=Falls Efficacy Scale, POMA=Performance-Oriented Mobility Assessment, FES-I=Falls Efficacy Scale International, PPA=Physiological Profile Assessment, SF-36=Medical Outcomes Study 36-Item Health Survey Questionnaire (version 2), APSI=Anterior-Posterior Stability Index, MLSI=Medial-Lateral Stability Index, OSI=Overall Stability Index, T2D=type 2 diabetes, mCTSIB=Modified Clinical Test of Sensory Integration of Balance, AP-ML=anteroposterior-mediolateral, COP=center of pressure, WB=weight bearing, NWB=non–weight bearing.
[b] Biodex Stability System, Biodex Medical Systems Inc, Shirley, New York.

(D'Silva et al., 2016)

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Effects of Diabetes Mellitus Type I with or without Neuropathy on Vestibular Evoked Myogenic Potentials

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Received: 30 Dec. 2011; Received in revised form: 10 Dec. 2012; Accepted: 4 Jan. 2013

Abstract- Diabetes mellitus type I is a metabolic disorder that affects multiple systems including the inner ear. Patients with diabetes mellitus commonly complain about dizziness, floating sensation, tinnitus and sweating. The aim of this study was to compare vestibular evoked myogenic potentials (VEMPs) between diabetic patients with or without neuropathy. Subjects included 14 patients with diabetes mellitus type I with polyneuropathy, 10 patients with diabetes mellitus type I without polyneuropathy and 24 healthy volunteers. Range of age in participants was 15-40 years old. The VEMPs were recorded with 500 Hz tone bursts with intensity at 95 dB. There was statistically significant difference between the groups in P13 and N23 latencies ($P<0.05$). There was no statistically significant difference between groups in absolute and relative amplitudes. Prolonged latencies of the VEMP suggest lesions in the retrolabyrinthine, especially in the vestibulospinal tract.

Acta Medica Iranica, 2013; 51(2): 107-112.

Keywords: Diabetes mellitus type I; Saccule; Sternocleidomastoid muscle; Vestibular evoked myogenic potentials; Vestibular System

Introduction

Diabetes mellitus is a group of metabolic diseases in which blood glucose level rises. The two most common types of diabetes mellitus are diabetes mellitus type I and type II (1). Diabetes mellitus is characterized by abnormal metabolism of carbohydrate, fat and protein resulting from defects in insulin secretion, insulin action or both. The chronic hyperglycemia of diabetes is associated with long term damage, dysfunction and failure of various organs especially the eyes, kidney, nerves, heart and blood vessels (2).

Most researchers believe that diabetes can cause different pathologies in humans (3-7). Bittar *et al.* report that glucose metabolism significantly influence the physiology of inner ear which is very active metabolically (2). The inner ear doesn't store energy, therefore minor variations in blood glucose affect its function and cause balance disorder (2). Patients with diabetes mellitus commonly complain about dizziness, floating sensation, tinnitus, weakness and sweating (3-7). However, studies in this area are very limited. Although it is known that diabetes affects many organ systems in the body and diabetic patients have vestibular problems, it is not yet clear which part of the vestibular system is the most affected part. On the other hand, in most cases in patients with diabetes, the balance of the system is evaluated using electronystagmography (ENG). Rigon *et al.* evaluated the vestibular system in patients with diabetes mellitus type I using ENG and their results showed that diabetes can affect the vestibular organ, even if there are no otoneurologic complaints (8). Other studies have shown that the range of vestibular organ impairment in diabetes mellitus type I seems to depend mainly on the presence and character of hypoglycaemic incidents and the duration of the disease (9). ENG only considers semicircular canals and superior vestibular nerve. While by using vestibular evoked myogenic potentials (VEMP) test, the examiner is able to assess

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Journal of Diabetes and Its Complications 31 (2017) 631–645

Contents lists available at ScienceDirect

Journal of Diabetes and Its Complications

journal homepage: WWW.JDCJOURNAL.COM

Exercise interventions for the improvement of falls-related outcomes among older adults with diabetes mellitus: A systematic review and meta-analyses

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ARTICLE INFO

Article history:
Received 1 June 2016
Received in revised form 26 August 2016
Accepted 28 September 2016
Available online 30 September 2016

Keywords:
Diabetes mellitus
Falls
Older
Exercise interventions
Balance training
Systematic review

ABSTRACT

Introduction: Falls as a complication of diabetes mellitus (DM) can have a major impact on the health of older adults. Previous reviews have demonstrated that certain exercise interventions are effective at reducing falls in older people; however, no studies have quantified the effectiveness of exercise interventions on falls-related outcomes among older adults with DM.
Methods: A systematic search for all years to September 2015 identified available literature. Eligibility criteria included: appropriate exercise intervention/s; assessed falls-related outcomes; older adults with DM. Effect sizes were pooled using a random effects model. Positive effect sizes favoured the intervention.
Results: Ten RCTs were eligible for the meta-analyses. Exercise interventions were more effective than the control condition for static balance (0.53, 95% CI: 0.13 to 0.93), lower-limb strength (0.63, 95% CI: 0.09 to 1.18), and gait (0.59, 95% CI: 0.22 to 0.96). No RCTs assessed falls-risk; one RCT reported 12 month falls-rate, with no differential treatment effect observed.
Conclusion: Exercise interventions can improve certain falls-related outcomes among older adults with DM. Substantial heterogeneity and limited numbers of studies should be considered when interpreting results. Among older adults, where DM burden is increasing, exercise interventions may provide promising approaches to assist the improvement of falls-related outcomes.

1. Introduction

Diabetes mellitus (DM) is a major public health concern with the number of cases rising in every country (International Diabetes Federation, 2015). The prevalence of diagnosed and undiagnosed DM has commonly been shown to increase with age up to approximately 85 years, after which time a plateau or slight decrease is typically observed (Sinclair, Dunning, & Rodriguez-Mañas, 2015). Recent estimates from the International Diabetes Federation (IDF) indicate that older adults (≥65 years) account for approximately 25% (94.2 million) of DM cases globally. This proportion is expected to grow substantially in coming years alongside global population ageing; such that by 2040, older adults are projected to constitute almost one-third (200.5 million) of people living with DM (International Diabetes Federation, 2015). DM among older adults is complicated by complexity of illness, increased risk of medical co-morbidities, early development of functional decline and concomitant risk of frailty and falls (International Diabetes Federation, 2013).

Falls as a complication of DM is increasingly being recognised as having a major impact on the overall health and quality of life of older adults (International Diabetes Federation, 2013). Falls are defined as "an unexpected event in which the person comes to rest on the ground, floor or other lower level" (Lamb, Jørstad-Stein, Hauer & Becker, 2005). In the general older community-dwelling population, approximately one in three older people fall each year (Moyer, 2012). Strikingly for people with DM, the combination of age (≥65 years) and DM increases the risk of recurrent falls by 67% (Pijpers et al., 2012); and older adults with DM are twice as likely to have injurious falls (Roman de Mettelinge, Cambier, Calders, Van Den Noortgate, & Delbaere, 2013). For an individual, falls can result in loss of confidence and reduced activity levels, potentially leading to loss of lower-limb muscle and bone strength (Karinkanta, Piirtola, Sievanen, Uusi-Rasi, & Kannus, 2010) and a fear of falling (Zijlstra et al., 2007). For the public health system, there are burgeoning costs associated with hospitalisations related to falls (Bradley, 2012).

One of the most common risk factors for falls is impaired postural control, or balance (Drootin, 2011; Ganz, Bao, Shekelle, & Rubenstein, 2007), with impairments possible in one or more of the motor, sensory and central nervous system components. Most commonly implicated in falls related to people with DM is peripheral neuropathy, whereby changes in the motor and/or sensory components of the foot and ankle potentially lead to balance deficits (Palma, Antigual, Martinez, Monnroy, & Gajardo, 2013). However,

Conflict of interest: None.
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http://dx.doi.org/10.1016/j.jdiacomp.2016.09.015
1056-8727/

Research Article

Positional Nystagmus in Patients Evaluated for Dizziness and Imbalance

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Received 31 August 2015; Accepted 3 January 2016

Academic Editor: Sampath Prasad

There is variability in the literature regarding the presence of positional nystagmus in healthy participants with reportedly normal vestibular and central nervous system function. This ranges from 7.5% to 88% and raises an important clinical question. If 88% of healthy participants have positional nystagmus then how is the clinician to interpret the presence of positional nystagmus in a patient presenting with dizziness and/or disequilibrium? The primary purpose of this investigation was to examine the prevalence and characteristics of positional nystagmus in patients evaluated specifically for dizziness and imbalance. Data was collected using retrospective chart review. 200 charts were randomly selected from all patients seen for evaluation of dizziness and imbalance over a period of eight months. Clinicians independently reviewed the data from positional testing for each chart. Nystagmus was present if there was a clear slow and fast phase component and there were three beats in a 10 s time window. Nystagmus direction and intensity data were collected. Results indicate positional nystagmus is present in 10.5% to 21% of patients evaluated for dizziness and imbalance. Use of liberal criteria for determining presence of positional nystagmus (i.e., 3 beats in 20 sec) may account for higher prevalence rates across other studies.

1. Introduction

Evaluation for positional nystagmus is an essential component of the vestibular and equilibrium evaluation [1, 2]. This assessment subtest is sometimes referred to as static positional testing and is differentiated from Dix-Hallpike positioning maneuvers used to identify posterior and anterior canal benign paroxysmal positional vertigo (BPPV) [1, 2]. During this test protocol, the clinician places the patient in different positions to look for provocation or modulation of nystagmus [1, 3]. Common test positions include supine, head right and/or body right, and head left and/or body left positions. The primary reason for moving the patient into these positions is to alter the orientation of the labyrinth relative to the earth gravitational vector [1, 3]. Changes in an existing spontaneous nystagmus or the provocation of nystagmus due to the position can occur because of central nervous system (CNS) involvement or peripheral vestibular involvement. Damage to the cerebellum, Arnold-Chiari malformation, multiple sclerosis, vertebrobasilar insufficiency, and even medication effects may all cause vertical positional nystagmus [1, 4, 5]. von Brevern et al. reported a variety of types of nystagmus observed in various static positions: geotropic, ageotropic, torsional, and downbeat for patients with definite migrainous vertigo [6]. We have reported on ageotropic horizontal nystagmus in patients with migrainous positional vertigo (MPV) [7].

The presence of positional nystagmus could also be an indicator of peripheral vestibular involvement. Of course, BPPV affecting the horizontal semicircular canals would be provoked using these types of positions [8, 9]. Placing a patient with spontaneous nystagmus resulting from an acute unilateral labyrinthine involvement into various positions may also alter the nystagmus. Likewise, when restoration of vestibular tone occurs with static compensation, placing the patient into different positions with varying levels of

Journal of Diabetes and Its Complications 31 (2017) 1275–1282

Contents lists available at ScienceDirect

Journal of Diabetes and Its Complications

journal homepage: WWW.JDCJOURNAL.COM

Impaired balance is related to the progression of diabetic complications in both young and older adults

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ARTICLE INFO

Article history:
Received 15 March 2017
Received in revised form 10 May 2017
Accepted 30 May 2017
Available online 4 June 2017

Keywords:
Diabetes
Diabetic complications
Impaired balance ability
Risk of falls
Young adult

ABSTRACT

Aims: To investigate the balance ability in younger and older adults with diabetes and evaluate the associations between balance ability and microvascular complications.
Methods: This cross-sectional observational study compared 162 participants and 177 controls with and without type 2 diabetes, respectively. Balance ability was assessed using two static (one-legged stance and postural sway area) and two dynamic (Timed Up and Go [TUG] and Functional Reach) tests. Diabetic microangiopathy was also evaluated.
Results: Participants with diabetes, including both younger (<50 years) and older (≥50 years) participants, showed significantly worse balance ability in all four tests and were more likely to have a history of falls than the controls (all $P < 0.01$). In all age groups, severe impairment of balance ability was associated with progression of diabetic microvascular complications. In all and older diabetic adults, a longer duration of diabetes ($P = 0.022$) and higher TUG test score ($P = 0.004$), and female sex ($P = 0.01$) and higher TUG score ($P = 0.001$), respectively, were related to a history of falls. On the other hand, among younger diabetic adults, only a non-significant association with longer duration of diabetes ($P = 0.066$) was observed.
Conclusions: Impaired balance ability correlates with microvascular diabetic complications. Accurate assessment of balance ability in adults with diabetes could predict the risk of falls, particularly benefiting people with diabetic complications.

1. Introduction

Among the elderly population, falls commonly lead to morbidity, disability, and loss of independence. The factors often reported to be associated with falls in older people include age, sex, muscle strength, impaired balance, sensory impairment, chronic diseases, psychotropic medication use, hypotension, and sarcopenia.[1,2] Further, recurrent falls and a fear of falling may have strong impacts on the quality of life,[3] and are independent risk factors for admission to nursing facilities.[4] In particular, older persons with diabetes are at a higher risk for falls and fractures than those without diabetes,[5,6] and diabetic complications such as peripheral neuropathy and impaired vision are known to affect gait and increase the risk for falls.[7–9] However, the association between impaired balance and microvascular diabetic complications has not yet been examined thoroughly, particularly in relatively young people with diabetes.

A fall is preceded by loss of balance, and balance ability is frequently evaluated by using the Berg Balance Scale and the Timed Up and Go (TUG) test. The latter has been recommended as a routine screening test for fall risk according to the guidelines published by the American Geriatric Society and the British Geriatric Society.[10,11] Impairment of balance is also evaluated clinically by using the one-legged stance test with the eyes open (OLS test),[12] the Functional Reach (FR) test,[13] and the body sway test.[14] In the present study, we hypothesized that even relatively young people with diabetes may have impaired balance. While these balance tests are useful tools for predicting falls among older adults, there have been only a few reports about whether they can effectively evaluate impairment of balance among younger adults with diabetes.

Furthermore, the associations between impaired balance and microvascular complications of diabetes have not been well

Conflict of Interests: None.

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http://dx.doi.org/10.1016/j.jdiacomp.2017.05.014
1056-8727/

Journal of Diabetes and Its Complications 31 (2017) 631–645

Contents lists available at ScienceDirect

Journal of Diabetes and Its Complications

journal homepage: WWW.JDCJOURNAL.COM

Exercise interventions for the improvement of falls-related outcomes among older adults with diabetes mellitus: A systematic review and meta-analyses

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ARTICLE INFO

Article history:
Received 1 June 2016
Received in revised form 26 August 2016
Accepted 28 September 2016
Available online 30 September 2016

Keywords:
Diabetes mellitus
Falls
Older
Exercise interventions
Balance training
Systematic review

ABSTRACT

Introduction: Falls as a complication of diabetes mellitus (DM) can have a major impact on the health of older adults. Previous reviews have demonstrated that certain exercise interventions are effective at reducing falls in older people; however, no studies have quantified the effectiveness of exercise interventions on falls-related outcomes among older adults with DM.

Methods: A systematic search for all years to September 2015 identified available literature. Eligibility criteria included: appropriate exercise intervention/s; assessed falls-related outcomes; older adults with DM. Effect sizes were pooled using a random effects model. Positive effect sizes favoured the intervention.

Results: Ten RCTs were eligible for the meta-analyses. Exercise interventions were more effective than the control condition for static balance (0.53, 95%CI: 0.13 to 0.93), lower-limb strength (0.63, 95%CI: 0.09 to 1.18), and gait (0.59, 95%CI: 0.22 to 0.96). No RCTs assessed falls-risk; one RCT reported 12 month falls-rate, with no differential treatment effect observed.

Conclusion: Exercise interventions can improve certain falls-related outcomes among older adults with DM. Substantial heterogeneity and limited numbers of studies should be considered when interpreting results. Among older adults, where DM burden is increasing, exercise interventions may provide promising approaches to assist the improvement of falls-related outcomes.

1. Introduction

Diabetes mellitus (DM) is a major public health concern with the number of cases rising in every country (International Diabetes Federation, 2015). The prevalence of diagnosed and undiagnosed DM has commonly been shown to increase with age up to approximately 85 years, after which time a plateau or slight decrease is typically observed (Sinclair, Dunning, & Rodriguez-Mañas, 2015). Recent estimates from the International Diabetes Federation (IDF) indicate that older adults (≥65 years) account for approximately 25% (94.2 million) of DM cases globally. This proportion is expected to grow substantially in coming years alongside global population ageing; such that by 2040, older adults are projected to constitute almost one-third (200.5 million) of people living with DM (International Diabetes Federation, 2015). DM among older adults is complicated by complexity of illness, increased risk of medical co-morbidities, early development of functional decline and concomitant risk of frailty and falls (International Diabetes Federation, 2013).

Falls as a complication of DM is increasingly being recognised as having a major impact on the overall health and quality of life of older adults (International Diabetes Federation, 2013). Falls are defined as "an unexpected event in which the person comes to rest on the ground, floor or other lower level" (Lamb, Jørstad-Stein, Hauer & Becker, 2005). In the general older community-dwelling population, approximately one in three older people fall each year (Moyer, 2012). Strikingly for people with DM, the combination of age (≥65 years) and DM increases the risk of recurrent falls by 67% (Pijpers et al., 2012); and older adults with DM are twice as likely to have injurious falls (Roman de Mettelinge, Cambier, Calders, Van Den Noortgate, & Delbaere, 2013). For an individual, falls can result in loss of confidence and reduced activity levels, potentially leading to loss of lower-limb muscle and bone strength (Karinkanta, Piirtola, Sievanen, Uusi-Rasi, & Kannus, 2010) and a fear of falling (Zijlstra et al., 2007). For the public health system, there are burgeoning costs associated with hospitalisations related to falls (Bradley, 2012).

One of the most common risk factors for falls is impaired postural control, or balance (Drootin, 2011; Ganz, Bao, Shekelle, & Rubenstein, 2007), with impairments possible in one or more of the motor, sensory and central nervous system components. Most commonly implicated in falls related to people with DM is peripheral neuropathy, whereby changes in the motor and/or sensory components of the foot and ankle potentially lead to balance deficits (Palma, Antigual, Martinez, Monrroy, & Gajardo, 2013). However,

Conflict of interest: None.

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http://dx.doi.org/10.1016/j.jdiacomp.2016.09.015
1056-8727/

PLOS ONE

RESEARCH ARTICLE

Functional Balance and Its Determinants in Older People with Diabetes

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OPEN ACCESS

Citation: Tsai Y-J, Yang Y-C, Lu F-H, Lee P-Y, Lee I-T, Lin S-I (2016) Functional Balance and Its Determinants in Older People with Diabetes. PLoS ONE 11(7): e0159339. doi:10.1371/journal.pone.0159339

Editor: Aristidis Veves, Harvard Medical School, UNITED STATES

Received: March 29, 2016

Accepted: June 30, 2016

Published: July 28, 2016

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Funding: This study was supported by research grants from the Ministry of Science and Technology, Taiwan (NSC 101-2314-B-006 -007, NSC 102-2314-B-006 -003; NSC 101-2314-B-006 -008; MOST 103-2314-B-006 -062).

Competing Interests: The authors have declared that no competing interests exist.

Abstract

Objective

To determine functional balance abilities of older adults with diabetes, and identify determinants of these abilities.

Methods

Eighty diabetic and 67 healthy non-diabetic community-dwelling older adults completed the Mini Mental Status Examination (MMSE) and questionnaires about their medical and fall histories. Participants were also assessed for vision, plantar sensitivity, muscle strength, and functional balance, including Functional Reach (FR), Five Times Sit-to-Stand (FTSTS), and 180° turn (TURN). In addition to between-group comparisons, hierarchical regression analysis was conducted to identify the independent determinants for each of the individual balance tasks for the diabetes and control group separately.

Results

The diabetes group had significantly greater body mass index, higher rate of cardiac disease, and poorer plantar sensitivity, mental status, grip and lower limb strength. The diabetes group performed significantly poorer in FTSTS and TURN (both $p<0.001$), but not FR ($p = 0.108$). The significant determinants for the balance tasks varied substantially between tasks and groups. For the diabetes group, they included visual and plantar sensitivity and MMSE for FR ($R^2 = 0.39$), ankle dorsiflexion strength for FTSTS ($R^2 = 0.377$), and plantar sensitivity, knee extension strength and MMSE for TURN ($R^2 = 0.391$). For the control group, knee extension strength emerged as the common and only significant determinant and only explained approximately 10% of the variance for FR and TURN.

Conclusions

Impairments in functional balance abilities were evident for older adults with diabetes. Their underpinning functional limitations were different for different tasks and were also different from those of the control group. Screening of functional balance and mental status, lower

Clinical Interventions in Aging

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ORIGINAL RESEARCH

Multiple diabetic complications, as well as impaired physical and mental function, are associated with declining balance function in older persons with diabetes mellitus

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Objective: To investigate whether there is a difference in balance function between older persons with and without diabetes mellitus (DM), and to identify whether mediating factors, such as diabetic complications, Instrumental Activities of Daily Living (IADL) score, Mini-Mental State Examination (MMSE) score, as well as hemoglobin A1c (HbA1c), fasting plasma glucose (FPG), serum total cholesterol (TC), triglycerides (TG), and low-density lipoprotein (LDL), are associated with balance function in older persons with DM.

Methods: In this cross-sectional study, a total of 208 older persons were divided into a DM group (n=80) and a control group who did not have DM (n=128). Balance function was evaluated with the Tinetti performance-oriented mobility assessment (POMA), which includes balance and gait subscales. Activities of daily living (ADL), IADL, and the MMSE were also measured. Fall incidents in last 12 months, the use of walking aids, fear of falling, comorbidities, and polypharmacy were recorded. Diabetic complications were recorded, and HbA1c, FPG, TC, TG, and LDL were measured in the patients of the DM group.

Results: Fall incidents in last 12 months were higher in the DM group than in the control group ($P<0.01$). POMA score as well as ADL and IADL scores were lower in the diabetic group than the control group ($P<0.05$). Within the diabetic group, the POMA score was positively related to the ADL score (odds ratio [OR], 11.7; 95% confidence interval [CI], 3.076–44.497; $P<0.01$), IADL score (OR, 16.286; 95% CI, 4.793–55.333; $P<0.01$), and MMSE score (OR, 10.524; 95% CI, 2.764–40.074; $P<0.01$), but was negatively related to age (OR, 7.707; 95% CI, 2.035–29.185; $P<0.01$) and diabetic complication (OR, 6.667; 95% CI, 2.279–19.504; $P<0.01$). Also, within the DM group, the decreased POMA score was associated with multiple diabetic complications (OR, 5.977; 95% CI, 1.378–25.926; $P<0.05$), decreased IADL score (OR, 10.288; 95% CI, 2.410–43.915; $P<0.01$), and MMSE score (OR, 13.757; 95% CI, 2.556–74.048; $P<0.01$).

Conclusion: Multiple diabetic complications, lower MMSE, ADL, and IADL scores were associated with declining balance function in the older persons with DM. These findings can alert physicians to detect and intervene earlier on declining balance in older persons with DM.

Keywords: diabetes mellitus, balance, POMA, fall, elderly, performance-oriented mobility assessment

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Introduction

Falls are the main cause of both fatal and nonfatal injuries in the elderly,[1] such as fractures and cerebral trauma, which increase morbidity and mortality and raise health care costs.[2,3] Diabetes mellitus (DM) affects >300 million individuals

Taylor & Francis
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Original Article

International Journal of Audiology 2005; 44:191–196

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Key Words
Benign paroxysmal positional vertigo (BPPV)
Vestibulopathy
Unilateral weakness
Caloric testing

Prevalence of vestibulopathy in benign paroxysmal positional vertigo patients with and without prior otologic history

Prevalencia de vestibulopatía en pacientes con vértigo postural paroxístico benigno (BPPV), con y sin historia previa de patología otológica

Abstract

The purpose of this study was to determine the prevalence of reduced or absent labyrinthine reactivity (vestibulopathy) in two groups of participants with posterior canal BPPV. One group had prior diagnosis of otologic disease (positive history group). No one in the second group had ever been diagnosed with otologic disease (negative history group). Caloric responses were retrospectively analyzed for the two groups. Patients with a positive history exhibited a greater prevalence of vestibulopathy than patients with a negative history. The positive history group, on average, also exhibited a larger unilateral weakness than those patients in the negative history group. We conclude that patients with BPPV and a history of otologic disease are more likely to present with vestibulopathy, than patients with BPPV and no history of otologic disease. This finding supports the benefit of complete vestibular evaluation in patients with BPPV to ensure comprehensive and successful treatment outcome.

Sumario

El propósito de este estudio fue determinar la prevalencia de reducción o ausencia de reactivation laberíntica (laberintopatía) en dos grupos de participantes después de BPPV del canal posterior. Un grupo tenía diagnóstico previo de patología otológica (grupo de historia positiva). Nadie del segundo grupo había sido diagnosticado con patología otológica (grupo de historia negativa). Las respuestas calóricas se analizaron retrospectivamente en los dos grupos. Los pacientes con una historia positiva mostraron una prevalencia mayor de vestibulopatía que los pacientes con historia negativa. El grupo de historia positiva, en promedio, también mostró una mayor debilidad unilateral que aquellos con una historia negativa. Concluimos que los pacientes con BPPV e historia de patología otológica presentan vestibulopatía con mayor frecuencia que los pacientes con BPPV sin historia de patología otológica. Estos hallazgos apoyan el beneficio de una evaluación vestibular completa en pacientes con BPPV para asegurar un tratamiento integral y exitoso.

Benign paroxysmal positional vertigo (BPPV) is a common cause of dizziness characterized by intense positionally-provoked vertigo of brief duration (Lanska & Remler, 1997; Bath et al, 2000; Pollak et al, 2002). BPPV is caused by interaction of the cupula of the affected semicircular canal and otoconia from the otolith organs (Schuknecht, 1969; Parnes & McClure, 1992). The otoconia, which are normally located in the utricle, become dislocated and move into the affected semicircular canal. When the head is placed in a provoking position, the otoconia move in the canal and displace the cupula. This results in vertigo and rotary nystagmus towards the affected ear (Belafsky et al, 2000; Macias et al, 2000). The nystagmus typically lasts for less than one minute and is fatigable after multiple positionings (Lanska & Remler, 1997; Konrad et al, 1999; Belafsky et al, 2000). Although all three semicircular canals may be affected, posterior canal BPPV is the most common form due to the anatomical position of this canal in relation to the utricle (Herdman & Tusa, 1996).

The test often considered the most useful in the diagnosis of vestibular diseases is the bithermal caloric test. The caloric test is used to stimulate the horizontal semicircular canals so that the response of each labyrinth can be compared. Each ear is separately stimulated using a warm and cool stimulus. The slow-phase velocity of the nystagmus is the value commonly used for assessment of the caloric response (Jacobson et al, 1997). Analysis of nystagmus slow-phase velocity allows for evaluation of the integrity of the right and left horizontal semicircular canals, separately, as well as for comparison of the strength of the response of each system. A difference of more than 20% between responses from the ears is considered clinically significant for a weak vestibular system (Jongkees et al, 1962). This finding is called a unilateral weakness, implying a vestibular disorder on the side with the diminished response (Jacobson et al, 1997). In a unilateral weakness, there is an asymmetry in the magnitude of information entering the brainstem, thus generating different nystagmus characteristics from each ear. The two ears are reacting differently (asymmetrically) to the same type of stimulation. The finding of asymmetric function or unilateral weakness in the vestibular system (Jacobson et al, 1997) may be termed a vestibulopathy.

There are numerous disorders that may cause a concomitant vestibulopathy and BPPV (Pollak et al, 2002). The literature suggests that vestibular neuritis, labyrinthitis, or Meniere's

ISSN 1499-2027 print / ISSN 1708-8186 online
DOI: 10.1080/14992020500057715

Received:
April 29, 2004
Accepted:
August 24, 2004

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Original Article

Diabetes Metab J 2012;36:64-69
http://dx.doi.org/10.4093/dmj.2012.36.1.64
pISSN 2233-6079 · eISSN 2233-6087

dmj
DIABETES & METABOLISM JOURNAL

Clinical Significance of the Presence of Autonomic and Vestibular Dysfunction in Diabetic Patients with Peripheral Neuropathy

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Background: We investigated the prevalence of diabetic autonomic neuropathy (DAN) and vestibular dysfunction (VD) in diabetic patients with peripheral neuropathy.
Methods: Thirty-five diabetic patients with peripheral neuropathy were enrolled from August 2008 to July 2009. All subjects underwent autonomic function tests. Nineteen of the patients (54.3%) underwent videonystagmography.
Results: Diabetic autonomic neuropathy was observed in 28 patients (80%). A mild degree of autonomic failure was observed in 18 patients (64.3%), and a moderate degree of autonomic failure was observed in ten patients (35.7%). Factors related to DAN included diabetic nephropathy (P=0.032), degree of chronic kidney disease (P=0.003), and duration of diabetes (P=0.044). Vestibular dysfunction was observed in 11 of 19 patients (57.9%). There was no significant association between DAN and VD.
Conclusion: Diabetic autonomic neuropathy was observed in 28 diabetic patients (80%) with peripheral neuropathy. Vestibular dysfunction was observed in nearly 60% of diabetic patients with peripheral neuropathy who complained of dizziness but showed no significant association with DAN. Diabetic patients who complained of dizziness need to examine both autonomic function and vestibular function.

Keywords: Diabetic autonomic neuropathy; Diabetic neuropathies; Vestibular dysfunction

INTRODUCTION

Diabetic autonomic neuropathy (DAN) is a type of diabetic polyneuropathy, usually accompanied by diabetic peripheral neuropathy [1,2]. Diabetic autonomic neuropathy is associated with the duration of the disease as well as poor glycemic control and has a negative effect on quality of life and life expectancy in affected patients [3,4].

Previous reports indicated that the vestibular system is involved in autonomic neural control for blood pressure and respiration according to positional change [5,6]. Vestibular dysfunction (VD) is a common comorbidity in patients with diabetes. Klagenberg et al. [7] reported a VD prevalence rate of 60% in a survey of 30 subjects with type I diabetes. Gawron et al. [8] reported that children and young adults with type I diabetes were vulnerable to VD, and VD prevalence was significantly higher in diabetic individuals than non-diabetic individuals [7-9]. Vestibular function plays an important role in postural stability with upright posture, along with the somatic and visual systems. Thus, VD increases the risk of falls due to

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Received: Jun. 13, 2011; Accepted: Aug. 29, 2011

RESEARCH ARTICLE

The Impact of Diabetic Neuropathy on Balance and on the Risk of Falls in Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Study

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Abstract

Introduction

Diabetic neuropathy (DN) is a prevalent complication of Type 2 Diabetes Mellitus (T2DM) with a major impact on the health of the affected patient. We hypothesized that mediated by the dysfunctionalities associated with DN's three major components: sensitive (lack of motion associated sensory), motor (impairments in movement coordination) and autonomic (the presence of postural hypotension), the presence of DN may impair the balance in the affected patients. Our study's main aim is to evaluate the possible association between the presence and severity of DN and both the balance impairment and the risk of falls in patients with T2DM.

Material and Method

In this cross-sectional study we enrolled, according to a consecutive-case population-based setting 198 patients with T2DM. The presence and severity of DN was evaluated using the Michigan Neuropathy Screening Instrument, a tool which allows both diagnosing and severity staging of DN. The balance impairment and the risk of falls were evaluated using four validated and standardized tools: Berg Balance Scale (BBS), Timed-up and Go test (TUG), Single Leg Stand test (SLS) and Fall Efficacy Scale (FES-I).

Results

The presence of DN was associated with significant decreases in the BBS score (40.5 vs. 43.7 points; p<0.001) and SLS time (9.3 vs. 10.3 seconds; p = 0.003) respectively increases in TUG time (8.9 vs. 7.6 seconds; p = 0.002) and FES-I score (38 vs. 33 points; p = 0.034).

Otology & Neurotology
31:1445–1450 © 2010, Otology & Neurotology, Inc.

Diabetes, Vestibular Dysfunction, and Falls: Analyses From the National Health and Nutrition Examination Survey

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Objective: Patients with diabetes are at increased risk both for falls and for vestibular dysfunction, a known risk factor for falls. Our aims were 1) to further characterize the vestibular dysfunction present in patients with diabetes and 2) to evaluate for an independent effect of vestibular dysfunction on fall risk among patients with diabetes.
Study Design: National cross-sectional survey.
Setting: Ambulatory examination centers.
Patients: Adults from the United States aged 40 years and older who participated in the 2001–2004 National Health and Nutrition Examination Survey (n = 5,86).
Interventions: Diagnosis of diabetes, peripheral neuropathy, and retinopathy.
Main Outcome Measures: Vestibular function measured by the modified Romberg Test of Standing Balance on Firm and Compliant Support Surfaces and history of falling in the previous 12 months.
Results: We observed a higher prevalence of vestibular dysfunction in patients with diabetes with longer duration of disease, greater serum hemoglobin A_{1c} levels and other diabetes-related complications, suggestive of a dose-response relationship between diabetes mellitus severity and vestibular dysfunction. We also noted that vestibular dysfunction independently increased the odds of falling more than 2-fold among patients with diabetes (odds ratio, 2.3; 95% confidence interval, 1.1–5.1), even after adjusting for peripheral neuropathy and retinopathy. Moreover, we found that including vestibular dysfunction, peripheral neuropathy, and retinopathy in multivariate models eliminated the significant association between diabetes and fall risk.
Conclusion: Vestibular dysfunction may represent a newly recognized diabetes-related complication, which acts as a mediator of the effect of diabetes mellitus on fall risk.
Key Words: Diabetes mellitus—Falls—Vestibular dysfunction.
Otol Neurotol 31:1445–1450, 2010.

Falls rank among the most morbid and costly health conditions affecting older individuals. Ten percent of falls result in serious injuries such as hip fractures (1), which carry extraordinarily high rates of morbidity and mortality (2). Falls commonly lead to restricted mobility and impaired capacity for self-care, and they are an independent risk factor for placement in a skilled nursing facility (3–6). The increased needs and diminished autonomy associated with falls come at tremendous cost to society (7–9). These costs seem to be rising: a recent study found that the prevalence and incidence of fall-induced injuries increased significantly in the last 25 years, even after adjusting for age (10). Coupled with an aging population, the scope and cost of this already significant public health problem will likely grow.

The risk of falling seems to be significantly elevated among patients with diabetes (11,12). The microangiopathic and metabolic disturbances associated with diabetes mellitus can cause peripheral neuropathy and retinopathy, which contribute to fall risk (13). A recent study also found that patients with diabetes are 70% more likely to have dysfunction of the vestibular system (14), which is a known risk factor for falls (15). At present, the association between vestibular dysfunction and diabetes mellitus is not well characterized. Moreover, the relative contributions of vestibular dysfunction and other diabetes-related complications (e.g. peripheral neuropathy, retinopathy) to the increased fall risk among patients with diabetes are unknown.

Here, we use data from the National Health and Nutrition Examination Survey (NHANES) from 2001 to 2004 to

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Can J Diabetes 40 (2016) 6–9

Contents lists available at ScienceDirect

Canadian Journal of Diabetes

journal homepage: www.canadianjournalofdiabetes.com

Practical Diabetes

Falls and Balance Impairments in Older Adults with Type 2 Diabetes: Thinking Beyond Diabetic Peripheral Neuropathy

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ARTICLE INFO

Article history:
Received 30 June 2015
Received in revised form
5 August 2015
Accepted 6 August 2015

Keywords:
aging
balance
cognition
falls
muscular
sensory

ABSTRACT

Older adults with type 2 diabetes have significantly higher incidence of falls than those without type 2 diabetes. The devastating consequences of falls include declines in mobility, activity avoidance, institutionalization and mortality. One of the most commonly identified risk factors associated with falls is impaired balance. Balance impairments and subsequent increased fall risk in older adults with type 2 diabetes are most commonly associated with diabetic peripheral neuropathy (DPN). Consequently, DPN has been the central focus of falls prevention research and interventions for older adults with type 2 diabetes. However, isolated studies have identified adults with type 2 diabetes without overt complications of DPN to also be at increased fall risk. It is known that the ability to maintain balance is a complex skill that requires the integration of multiple sensorimotor and cognitive processes. Emerging evidence suggests that diabetes-related subtle declines in sensory functions (somatosensory, visual and vestibular), metabolic muscle function and executive functions may also contribute to increased fall risk in older adults with type 2 diabetes. Knowledge of these type 2 diabetes-related sensorimotor and cognitive deficits may help to broaden approaches to falls prevention in older adults with type 2 diabetes. Therefore, the purpose of this mini review is to describe the impact of type 2 diabetes on sensorimotor and cognitive systems that may contribute to increased fall risk in older adults with type 2 diabetes.

Mots clés :
vieillissement
équilibre
processus cognitifs
chutes
musculaire
sensoriel

RÉSUMÉ

Les personnes âgées souffrant du diabète de type 2 ont un nombre considérablement plus élevé de chutes que ceux qui ne souffrent pas du diabète de type 2. Les conséquences dévastatrices des chutes sont les suivantes : le déclin de la mobilité, l'évitement de l'activité, l'institutionnalisation et la mortalité. L'un des facteurs de risque de chutes le plus fréquemment observé concerne les troubles de l'équilibre. Les troubles de l'équilibre et l'augmentation subséquente du risque de chutes chez les personnes âgées souffrant du diabète de type 2 sont plus fréquemment associés à la neuropathie diabétique périphérique (NDP). Conséquemment, la NDP a constitué le point central de la recherche sur la prévention des chutes chez les personnes âgées souffrant du diabète de type 2. Cependant, des études isolées ont également établi que les adultes souffrant du diabète de type 2 sans complications avérées de NDP étaient également exposés au risque de chutes. Il est connu que la capacité à maintenir l'équilibre est une habileté complexe qui nécessite l'intégration de multiples processus cognitifs et sensorimoteurs. Des données scientifiques émergentes montrent que le déclin subtil du fonctionnement des systèmes sensoriels lié au diabète (somatosensoriel, visuel et vestibulaire), du fonctionnement du métabolisme musculaire et du fonctionnement exécutif peut également contribuer à l'augmentation du risque de chutes chez les personnes âgées souffrant du diabète de type 2. Le fait de connaître ces déficits sensorimoteurs et cognitifs liés au diabète de type 2 peut contribuer à élargir les approches sur la prévention des chutes chez les personnes âgées souffrant du diabète de type 2. Par conséquent, l'objectif de cette mini-revue est de décrire les conséquences du diabète de type 2 sur les systèmes sensorimoteurs et cognitifs qui peuvent contribuer à l'augmentation du risque de chutes chez les personnes âgées souffrant du diabète de type 2.

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1499-2671
http://dx.doi.org/10.1016/j.jcjd.2015.08.005

Perspective

Impact of Diabetic Complications on Balance and Falls: Contribution of the Vestibular System

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Diabetes causes many complications, including retinopathy and peripheral neuropathy, which are well understood as contributing to gait instability and falls. A less understood complication of diabetes is the effect on the vestibular system. The vestibular system contributes significantly to balance in static and dynamic conditions by providing spatially orienting information. It is noteworthy that diabetes has been reported to affect vestibular function in both animal and clinical studies. Pathophysiological changes in peripheral and central vestibular structures due to diabetes have been noted. Vestibular dysfunction is associated with impaired balance and a higher risk of falls. As the prevalence of diabetes increases, so does the potential for falls due to diabetic complications. The purpose of this perspective article is to present evidence on the pathophysiology of diabetes-related complications and their influence on balance and falls, with specific attention to emerging evidence of vestibular dysfunction due to diabetes. Understanding this relationship may be useful for screening (by physical therapists) for possible vestibular dysfunction in people with diabetes and for further developing and testing the efficacy of interventions to reduce falls in this population.

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[D'Silva LJ, Lin J, Staecker H, et al. Impact of diabetic complications on balance and falls: contribution of the vestibular system. *Phys Ther*. 2016;96:400–409.]

Published Ahead of Print:
August 6, 2015
Accepted: July 27, 2015
Submitted: January 5, 2015

Otology & Neurotology
38:379–385 © 2016, Otology & Neurotology, Inc.

Otolith Dysfunction in Persons With Both Diabetes and Benign Paroxysmal Positional Vertigo

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Objective: Vestibular dysfunction is a well-recognized complication of type 2 diabetes (DM) that may contribute to increased fall risk. The prevalence of benign paroxysmal positional vertigo (BPPV) is higher in people with DM. The impact of DM on the otolith organs of the vestibular system in people with BPPV is unknown. The purpose of this study was to analyze otolith function using vestibular-evoked myogenic potential (VEMP) tests in people with DM and concurrent BPPV (BPPV + DM), and to examine the relationships between VEMP variables and diabetes-related variables.
Study Design: Prospective, cross-sectional study.
Setting: Tertiary academic medical center.
Subjects and Methods: Participants 40 to 65 years were recruited in four groups: controls (n = 20), people with DM (n = 19), BPPV (n = 18), and BPPV + DM (n = 14). Saccule and utricle function were examined using cervical VEMP (cVEMP) and ocular VEMP (oVEMP), respectively. Diabetes-related variables such as HbA1c, duration of diabetes, and presence of sensory impairment due to diabetes were collected.
Results: The frequency of abnormal cVEMP responses was higher in the DM ($p = 0.005$), BPPV ($p = 0.003$), and BPPV + DM ($p < 0.001$) groups compared with controls. In the participants with diabetes, higher HbA1c levels were correlated with prolonged P1 ($p = 0.03$) and N1 latencies ($p = 0.03$). The frequency of abnormal oVEMP responses was not different between groups ($p = 0.2$).
Conclusion: Although BPPV and DM may independently affect utricle and saccule function, they do not seem to have a distinct cumulative effect. **Key Words:** Benign paroxysmal positional vertigo—Diabetes—Vestibular-evoked myogenic potential.

Otol Neurotol **38**:379–385, 2017.

Type 2 diabetes (DM) affects 9.3% of the US population (1) and is predicted to affect one in three people by the year 2050 (2). Diabetic complications such as peripheral neuropathy and retinopathy contribute significantly to balance deficits, increasing fall risk (3,4). Vestibular dysfunction may be considered another possible complication of diabetes (5–7). In people with diabetes and vestibular dysfunction, the risk of falls increases more than two times, after adjusting for peripheral neuropathy and retinopathy (6). Fall prevention is a major clinical focus for people with diabetes, hence examining the effect of diabetes on the vestibular system merits attention.

Animal studies have shown that diabetes affects the saccule, causing morphological changes, such as type I hair cell loss (8,9), whereas clinical research has shown that in people with DM, utricle and saccule function are significantly impaired compared with age-matched, healthy controls (10,11). Degeneration of the maculae of the utricle and saccule can cause otoconia fragments to dislodge, which is the cause of one common peripheral vestibular condition, benign paroxysmal positional vertigo (BPPV) (12,13). Recent studies have shown that BPPV is present in higher frequency in people with both type 1 and type 2 diabetes compared with healthy controls (14–16).

Vestibular-evoked myogenic potentials (VEMP) are objective, and reliable electrophysiological tests that measure otolith function (17). The cervical VEMP

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This work was conducted at the University of Kansas Medical Center, and was supported by an institutional grant T32HD057850 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development and a grant from the Kansas Partners in Progress, Inc. REDCap at the University of Kansas Medical Center is supported by CTSA grant (CTSA Award # UL1TR000001) from NCRR and NCATS awarded to the University of Kansas Medical Center.
The authors disclose no conflicts of interest.
DOI: 10.1097/MAO.0000000000001309

Otology & Neurotology
37:553–557 © 2016, Otology & Neurotology, Inc.

Vascular and Neuroepithelial Histopathology of the Saccule in Humans With Diabetes Mellitus

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Hypothesis: This study aimed to determine if there are quantitative differences in the neuroepithelium and microvasculature of the saccule between subjects with and without diabetes mellitus (DM).
Background: Histopathologic changes that may underlie the association between DM and vestibular dysfunction have not been characterized in humans.
Methods: Human temporal bones (HTBs) from 39 subjects with DM (n = 16 type I DM [T1DM], n = 23 type II DM [T2DM]) were compared with 40 group age-matched controls. Vessel wall thickness was measured from the saccular arteriole. Type I and type II vestibular hair cell (VHC) counts were performed on perpendicularly oriented saccular maculae using differential interference contrast microscopy (T1DM: 5HTB/3 subjects; T2DM: 9HTB/8 subjects; controls: 25HTB/20 subjects).
Results: The mean density of type I VHCs was 16 to 17% lower in the DM groups compared to controls (T1DM 52.21 [4.26], T2DM 53.3 [5.34], control 63.14 [2.49] cells/mm^2, $p = 0.02$). There were no differences between T1DM, T2DM, and control groups in type II VHC density (T1DM 40.89 [5.17], T2DM 40.44 [6.93], control 42.80 [1.79] cells/mm^2, $p = 0.92$) or in mean vessel wall thickness (T1DM 2.23 [0.62], T2DM 2.18 [0.53], control 2.00 [0.53] μm, $p = 0.26$).
Conclusion: Neuroepithelial pathology, manifested as lower density of type I VHCs, was observed in the saccules of subjects with DM. Saccular microangiopathy, expressed as alterations in arteriole thickness, was not observed. These findings are consistent with histologic observations in animals with experimentally induced diabetes. DM may have a selective and deleterious effect on human vestibular sensory epithelia.
Key Words: Diabetes mellitus—Histopathology—Human—Labyrinth—Saccule—Temporal bone—Vestibular.

Otol Neurotol 37:553–557, 2016.

The worldwide incidence and prevalence of diabetes mellitus (DM) are increasing at epidemic rates (1,2). In multiple organ systems, the chronically high glucose concentrations that characterize the disease cause capillaries and small arterioles to accumulate basement membrane material that thickens vessel walls and alters vascular permeability (3). Known as diabetic microangiopathy, this hyperglycemia-induced microvascular pathology results in the most commonly recognized diabetes complications: retinopathy, nephropathy, and peripheral neuropathy (3).

Diabetes may also result in pathology and dysfunction of the inner ear. DM is epidemiologically associated with sensorineural hearing loss (4–6). The cochleae of humans and animals with DM manifest corresponding microangiopathic and neuroepithelial changes, including capillary basement membrane thickening in the stria vascularis, thickening and occlusion of cochlear arterioles and arteries, and variable degrees of cochlear hair cell and spiral ganglion cell loss (7,8). Adults with DM are also at increased risk of vestibular dysfunction and falls, independent of the presence of peripheral neuropathy and retinopathy (9,10). When comparing vestibular test results to those of controls, subjects with DM have more dysfunction of the otolith organs, superior and lateral semicircular canals, and/or their corresponding vestibular nerve afferents (11–13). However, any corresponding vestibular end organ pathology in humans with DM remains uncharacterized.

A series of light and electron microscopic investigations of pathologic changes in the saccule was carried out in rats with drug-induced diabetes (14–16). Unlike controls of the same age, saccules from rats with longer durations of diabetes had scattered type I vestibular hair cell (VHC) degeneration but neither group had type II

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This project was funded by NIH NIDCD U24 DC011968-01, International Hearing Foundation, Starkey Foundation, and 5M Lions International. Dr. Kaya is also funded by the Scientific and Technological Research Council of Turkey (TUBITAK).
The authors disclose no conflicts of interest.

NEW PROTOCOL SUMMARY FORM

Principal Investigator: Jack Wazen, MD
Sub Investigators: Herbert Silverstein, MD; Julie Daugherty, PhD, NP-C; Richard Gans, PhD; Carmelo Ortega, AuD, Joshua Smith, DO
Drug, Device or Procedure: Canalith repositioning maneuvers
Protocol Title: *The Effect of Canalith Repositioning Maneuvers on the Postural Stability of Patients with Diabetes and Migraine.*
Lay Title (Must be at or below an 8th Grade Reading Level): *How do diabetes and migraine impact the effectiveness of treatment in people who have benign positional vertigo?*

Enter a brief description of study put into lay terms:
This study is designed to look at how benign positional vertigo affects balance and stability, comparing the differences between people with and without migraine disorder or diabetes. Migraine and diabetes are both risk factors for balance disorders. Benign positional vertigo is known to affect balance function for a period of time even after an episode of vertigo has ended. Our main goal is to see how postural stability changes after positional vertigo has been treated with a repositioning maneuver in a group of individuals with a history of diabetes and in a group with migraine headaches. We will compare these results to a control group (no previous medical history of diabetes or migraine headaches).

Please include if the drug, device or procedure is FDA approved and for what indication:
N/A

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Role of Audiology

- Interview and Medical History- Review of Systems
- Inclusion of Screening or Diagnostic Protocols
- Recommendations for additional evaluation or management

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Intervention strategies & Fall Risk management

Screening protocols (< 5 min)

- Interview for history of falls or elevated self-report fear of falling
- Timed up-and-go test (TUG)
- Functional reach test
- Dynamic Gait Index (DGI)
- Clinical Test of sensory integration of balance (CTSIB)
- Test for BPPV - modified Hallpike (mHallpike)

Advanced assessments

- Computerized Dynamic Posturography (CDP) or Gans SOP, CTSIB
- VideoNystagmography (VNG)
- Vestibular Evoked Myogenic Potential (VEMP)
- Rotary Chair

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Treatment & Management

- Canalith repositioning maneuvers (CRM) for active BPPV
- Vestibular Rehabilitation Therapy (VRT)
- Balance Retraining Therapy (BRT)
- Activities of Daily Living (ADL)
- Addressing fall risks in the home environment
- Assistive Device appropriate for inside and/or outside the home

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Thank You

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