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The impact of diabetes on mobility, balance, and recovery after repositioning maneuvers in individuals with benign paroxysmal positional vertigo

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ABSTRACT

Aim: The prevalence of benign paroxysmal positional vertigo (BPPV) is higher in people with type 2 diabetes (DM). The impact of DM on mobility, balance, and management of BPPV is unknown. This prospective study compared symptom severity, mobility and balance before and after the canalith repositioning maneuver (CRM) in people with posterior canal BPPV canalithiasis, with and without DM.
Methods: Fifty participants, BPPV ($n = 34$) and BPPV + DM ($n = 16$) were examined for symptom severity (dizziness handicap inventory, DHI), mobility (functional gait assessment, FGA), and postural sway (using an accelerometer in five conditions) before and after the CRM. The number of maneuvers required for symptom resolution was recorded.
Results: At baseline, no differences in DHI or FGA scores were seen between groups, however, people with BPPV + DM had higher sway velocity in the medio-lateral direction in tandem stance ($p < 0.01$). After treatment, both groups improved in DHI and FGA scores ($p < 0.01$), with no differences between groups. Decrease in sway velocity in the mediolateral direction ($p = 0.003$) were seen in tandem stance in persons with BPPV + DM. There were no differences between the groups in the number of CRMs provided.
Conclusions: This pilot study showed no differences in symptom severity, mobility deficits or efficacy of CRM treatments in people with posterior canal BPPV canalithiasis with and without DM. Future studies examining the impact of the severity and duration of diabetes, as well as the influence of diabetic peripheral neuropathy on functional performance are essential.

1. Introduction

The vestibular system plays an important role in maintaining balance in static and dynamic conditions. It provides information about the position and motion of the body with respect to earth's vertical.[1] Within the peripheral vestibular system, the semicircular canals provide sensory input regarding head velocity; while the otolith organs (utricle and saccule) register linear acceleration and head tilt.

Vestibular dysfunction has been recognized as a complication of type 2 diabetes (DM), and has been reported to be 70% higher in people with DM, compared to age matched controls.[2] In people with diabetes, vestibular dysfunction, and complaints of dizziness, the risk of falls is two times higher after accounting for peripheral neuropathy and retinopathy.[3] Both central and peripheral vestibular dysfunction has been observed in type 1 and type 2 diabetes.[4–10] Metabolic stress due to hyperglycemia has been shown to cause loss of type 1 hair cells in the saccule,[8] and lysis of the myelin of the vestibulocochlear nerve[7] in experimentally induced diabetic animal models; while clinical studies have shown peripheral vestibular organ dysfunction.[10,11]

One common vestibular condition, benign paroxysmal positional vertigo (BPPV) has been seen in higher frequency in people with diabetes. Cohen et al. reported 14% of the individuals in their sample with BPPV had a history of diabetes,[12] while D'Silva et al. noted that BPPV was seen in 46% of individuals with type 2 diabetes compared to 37% without diabetes.[13] In a histopathology study examining human temporal bones, Yoda et al. found a significantly higher prevalence of BPPV in people with type 1 diabetes compared to age matched controls.[14] In addition, the presence of comorbidities like diabetes and hypertension have been shown to increase the risk of recurrence of BPPV significantly.[15] The combination of hypertension, diabetes, and osteoarthritis increased the recurrence rate of BPPV 4.55 times.[15] In

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BPPV, calcium carbonate crystals called otoconia, fall off the gelatinous membrane of the utricle and saccule and enter the semicircular canals. One reason for the detachment of the otoconia is underlying degeneration of the utricle and saccule.[16,17] The otoconia fragments enter the semicircular canal causing movement of the endolymph within the semicircular canal. Endolymph movement is perceived as vertigo (spinning), even after head movements have ceased.[16,18,19] Otoconia fragments can enter the anterior, posterior or lateral semicircular canals. Posterior canal BPPV is the most common variant, as it is seen in 91% of patients compared to 9% in the lateral canal.[20] Another variant of BPPV is based on whether the otoconia are free floating in the semicircular canal (canalithiasis) or attached to the cupula (cupulolithiasis). Successful treatment of BPPV depends on identifying the canal involved, making the diagnosis of canalithiasis or cupulolithiasis, and providing the specific treatment maneuver. The gold standard test for diagnosing posterior canal BPPV is the Dix-Hallpike test (refer to Bhattacharya et al. for a description of the test).[16] The treatment of choice for treating posterior canal BPPV canalithiasis is the canalith repositioning maneuver (CRM).[21,22] The success rate of treating posterior canal BPPV canalithiasis with the CRM is significantly higher compared to the treatment of anterior, or lateral canal BPPV canalithiasis or cupulolithiasis. The CRM is a series of head movements to guide the otoconia back into the utricle and has a success rate of up to 85% with a single treatment maneuver.[16,23]

Benign paroxysmal positional vertigo causes a position dependent vertigo and is associated with loss of balance and frequent falls.[24–26] Due to vertigo, individuals with BPPV restrict their daily activities with increased missed days at work resulting in decreased productivity.[27,28]

Presently, we do not have a clear understanding of how DM may affect the clinical presentation of people with BPPV when they are symptomatic, or the efficacy of the CRM to resolve BPPV symptoms. The main objective of this pilot study was to identify if the presence of diabetes affected symptom severity, mobility and balance in people with BPPV when symptomatic, and changes in these symptoms after the resolution of vertigo with the CRM in people with posterior canal BPPV canalithiasis. Our second objective was to determine if the presence of diabetes influenced the efficacy of the CRM. The efficacy of treatment is significantly higher in people with posterior canal BPPV canalithiasis, hence, for this study we excluded individuals who had anterior or lateral canal BPPV, people with bilateral BPPV, and those with the cupulolithiasis variant of BPPV.

The findings of this study will be useful to health care professionals to recognize mobility and balance deficits due to diabetes in the presence of BPPV and the efficacy of the CRM in this population.

2. Methods

2.1. Study design

This prospective study, evaluated two groups of participants, those with BPPV and those with BPPV + DM, at baseline and after treatment. In this single-blinded study, the primary investigator (LD) was blinded to the diabetes status of participants during both data collection time points. The Human Subjects Committee at the University of Kansas Medical Center approved the research protocol. All participants signed institutionally approved written informed consent prior to participation in the study.

2.2. Participants

Participants were recruited through physician referral from the Kansas University neuro-otology clinic, as well as internal medicine, and family medicine clinics in the area. Individuals between 40 and 80 years of age with a diagnosis of unilateral posterior canal BPPV canalithiasis were recruited for this study.

The diagnosis of posterior canal BPPV was based on the presence of torsional up beating nystagmus in the Dix-Hallpike position, where the patient was supine-lying with the head rotated 45 degrees and extended 30 degrees, using videonystagmography (Micromedical, Visual Eyes 2002). The nystagmus had a brief latency, lasted less than 60 s, and was associated with complaints of vertigo.[16] Participants were excluded if they presented with any of the following: (1) a history of neurological disease including stroke, multiple sclerosis, Parkinson's disease, intracranial tumor, (2) a history of Meniere's disease, (3) received chemotherapy or ototoxic and/or neurotoxic medications, (4) a history of traumatic head injury, (5) a BMI greater than 45 kg/m^2, or (6) musculoskeletal or integumentary conditions that would impair balance. In addition, participants were excluded if videonystagmography revealed anterior or lateral canal BPPV canalithiasis, cupulolithiasis in any canal, or bilateral BPPV.

2.3. Study procedure

Fig. 1 illustrates the sequence of study procedures. Once inclusion/exclusion criteria and the diagnosis of unilateral posterior canal BPPV canalithiasis were confirmed, baseline outcome measures were collected.

After collection of baseline outcome measures, all participants received the CRM. Subjects were given restrictions to follow for 48 h, which included no bending, no looking overhead, and no sleeping on the affected side.[29]

Participants returned for follow up between 7 to10 days of the initial evaluation, and the Dix-Hallpike was repeated using videonystagmography to determine if the BPPV had resolved. If nystagmus and vertigo persisted, participants continued to receive treatment maneuvers with follow up between 7 to 10 days, until resolution of symptoms. Once participants had no complaints of vertigo and a negative Dix-Hallpike test, they were considered symptom-free, and post-treatment outcome measures were collected. Next, all participants were screened for the presence of sensory impairment using the Michigan Neuropathy Screening Instrument (MNSI). Participants were classified as having peripheral neuropathy if their physical exam score was ≥2.0 (sensitivity of 65%, specificity of 83%).[31]

Lastly, the assessor was unblinded and for all participants a detailed medical history, list of medications, the presence or absence of diabetes, hypertension and BMI was collected through history taking, which was also confirmed through the electronic health records. To characterize diabetes severity, glycosylated hemoglobin (HbA1c) was tested via a disposable finger stick testing kit (Metrika A1cNow$^+$ Bayer, Tarrytown NY) for all participants.

2.4. Outcome measures

The following outcome measures were collected at baseline and after resolution of vertigo

Dizziness Handicap Inventory (DHI): This is a standardized measure of self-report activity limitation and participation restriction due to either dizziness or unsteadiness.[30] It is a 25-item questionnaire with three subscales: functional, emotional and physical. It has a high test–retest reliability (r = 0.9),[30] and it is responsive to change in the vestibular population[32–34] with an 18-point change on the DHI considered clinically meaningful.[30] A DHI total score between 0 and 30 is considered a mild perception of handicap; 31–60 is moderate, and 61–100 points' severe perception of handicap.[35] Persons with higher scores on the DHI have been shown to have greater functional impairments and higher number of falls.[35]

Functional Gait Assessment (FGA): The FGA is a 10-item functional mobility test,[36,37] that is scored on a four point ordinal scale (0–3) with a higher score indicating greater stability during functional mobility. The various items on the test include: walking at normal

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