CoDAS
ISSN 2317-1782 (Online version)

Original Article
Artigo Original

Postural balance in type 2 diabetics with vertigo, dizziness and/or unsteadiness

Equilíbrio postural em diabéticos tipo 2 com vertigem, tontura e/ou instabilidade

Jackeline Yumi Fukunaga[1]
Rafaela Maia Quitschal[1]
Sergio Atala Dib[2]
Maurício Malavasi Ganança[3]
Heloisa Helena Caovilla[3]

Keywords

Diabetes mellitus
Postural balance
Dizziness
Vertigo
Vestibular
Labyrinth

ABSTRACT

Purpose: To evaluate the postural balance of type 2 diabetics with vertigo, dizziness, and/or unsteadiness. **Methods:** limit of stability, pressure center displacement area, and sway velocity of 20 patients with type 2 diabetes were compared with 22 controls using the Balance Rehabilitation Unit (BRUTM, Medicaa) posturography. **Results:** Compared to the control group, patients with type 2 diabetes showed a significantly lower limit of stability and a significantly higher-pressure center displacement area on a firm surface with eyes open, eyes closed, and horizontal vestibular-visual interaction; and higher sway velocity on a firm surface with eyes open and with eyes closed. **Conclusion:** type 2 diabetics with vertigo, dizziness, and/or imbalance compromised postural balance related to visual stimuli and vestibular-visual interaction and moderate impairment in the quality of life.

Descritores

Diabetes mellitus
Equilíbrio postural
Tontura
Vertigem
Vestíbulo do labirinto

RESUMO

Objetivo: avaliar o equilíbrio postural em diabéticos tipo 2 com vertigem, tontura e/ou instabilidade. **Método:** área do limite de estabilidade, área de deslocamento do centro de pressão e velocidade de oscilação de 20 pacientes com diabetes mellitus tipo 2 com vertigem, tontura e/ou instabilidade foram comparados a um grupo controle com 22 indivíduos hígidos à posturografia do *Balance Rehabilitation Unit (BRU™)*. **Resultados:** a área do limite de estabilidade dos diabéticos tipo 2 foi significantemente menor do que a do grupo controle. Os diabéticos tipo 2 apresentaram valores significantemente maiores quanto à área de deslocamento do centro de pressão, em superfície firme, de olhos abertos, olhos fechados e com interação visuovestibular na direção horizontal; e quanto à velocidade de oscilação em superfície firme, de olhos abertos e olhos fechados. **Conclusão:** diabéticos tipo 2 com vertigem, tontura e/ou instabilidade apresentam comprometimento do equilíbrio postural relacionado com estímulos visuais e de interação visuovestibular e prejuízo moderado na qualidade de vida.

Correspondence address:
Jackeline Yumi Fukunaga.
Rua Napoleão de Barros 590, Vila Clementino, São Paulo (SP),Brasil, CEP: 04024-002.
E-mail: jackeline_fukunaga@yahoo.com.br

Received: March 07, 2019.

Accepted: December 14, 2019.

Study conducted at the Departamentos de Otorrinolaringologia e Cirurgia de Cabeça e Pescoço e de Fonoaudiologia, Universidade Federal de São Paulo/Escola Paulista de Medicina - UNIFESP/EPM - São Paulo (SP), Brasil.

[1] Programa de Pós-graduação em Distúrbios da Comunicação Humana, Departamento de Fonoaudiologia, Universidade Federal de São Paulo/Escola Paulista de Medicina - UNIFESP/EPM - São Paulo (SP), Brasil.

[2] Disciplina de Endocrinologia, Departamento de Medicina, Universidade Federal de São Paulo/Escola Paulista de Medicina - UNIFESP/EPM - São Paulo (SP), Brasil.

[3] Disciplina de Otologia e Otoneurologia, Departamento de Otorrinolaringologia e Cirurgia de Cabeça e Pescoço, Universidade Federal de São Paulo/Escola Paulista de Medicina - UNIFESP/EPM - São Paulo (SP), Brasil.

Conflict of interest: nothing to declare.

Financial support: Scholarship granted by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). There was no number of funding processes for grants. Financing was carried out through its Promotion Programs: Social Demand – SD and Programa de Excelência Acadêmica - PROEX.

INTRODUCTION

Diabetes Mellitus (DM) is a heterogeneous group of metabolic disorders with hyperglycemia as a common sign, resulting from defects in the action and/or secretion of insulin[1].

DM is one of the main problems of the 21st century. One of the main challenges is that approximately 212.4 million people, or 50% of individuals between 20 and 79 years old, unknowingly present the disease. DM is debilitating and can lead to death. It affects those who are at the most productive age and reduces the life expectancy of the elderly population. Also, it is a burden to national health budgets, reducing productivity, slowing economic growth, and burdening health systems[2].

The increase in the DM prevalence has been identified worldwide due to the increase in life expectancy and the consequent growth of the elderly population, in addition to the influence of lifestyle habits such as sedentary, lifestyle, diets rich in sugars, fats, and calories, resulting in overweight and obesity[2].

The International Diabetes Federation estimated that the world population with DM would be 425 million in 2017 and that it would reach 629 million in 2045. It was estimated that the number of individuals with DM was 12.5 million in Brazil, in 2017, occupying the 4th place in the world ranking, and reaching 20.3 million people in 2045. In addition, it was estimated that the number of individuals with undiagnosed DM would be 3.7 million[2].

Type 2 diabetes mellitus (DM2) is the most common type, affecting 90% to 95% of cases. It is characterized by defects in the action and secretion of insulin and the regulation of hepatic glucose production[1].

DM can cause micro and macrovascular complications that affect several organs in terms of anatomical, structural, and functional aspects[3].

DM has also been postulated as vestibular-toxic due to its microangiopathic character, which would cause ischemia of vestibular structures[4], and, consequently, may cause structural and functional changes in the vestibular system[5].

Glucose metabolism has a major influence on the physiology of the inner ear; small variations in blood metabolites would influence its functioning, causing vestibular or auditory changes[6].

Individuals with DM are 70% more likely to have vestibular disorders[4]. The relationship between the severity of DM and vestibular dysfunction was identified; the prevalence of vestibular disorders would be higher in long-term cases of the disease when there is difficulty in controlling glycemia and serum levels of glycated hemoglobin (HbA1c) are elevated[7]. Vestibular dysfunction is one of the complications of DM that can compromise postural balance, increasing the risk of falls[7,8].

Postural balance can be defined as the human being's ability to remain erect and perform body movements without oscillations or falls. Its maintenance is determined by the integration of information in the central nervous system, coming from the vestibular, visual, and proprioceptive systems that trigger ocular and spinal reflexes[9]. The compromise of several systems that contribute to the maintenance of postural balance predisposes the diabetic population to the risk of falls and their consequences. Also, the consequences of falling in these individuals are potentially more serious due to impaired healing[10].

Posturography quantitatively measures postural instability, assists in the analysis of the dysfunction that causes body imbalance[11], complements conventional vestibular diagnosis tests, and can identify the first signs of impaired postural balance[12].

The posturographic measure most used in the evaluation of postural control is the pressure center. The pressure center is the point of application of the resultant of the vertical forces that act on the support surface and represent the collective result of the postural control system and the gravitational force. In the upright posture, the support base corresponds to the polygon formed by the outer edges of the feet. The stability limit can be defined as the distance that the individual can move in the antero-posterior and medial-lateral direction without losing balance, using this support base[11].

This research was motivated by the possibility of posturography being able to provide information about postural control in different conditions, with virtual and sensory integration stimuli, which could contribute to the characterization of the postural balance disorder. These procedures' findings can complement the information from the vestibular functional assessment. Also, there are few articles on cases of DM2 complaining of dizziness, vertigo, and/or instability.

Objective: to assess postural balance in type 2 diabetics with vertigo, dizziness, and/or instability.

METHODS

This controlled, cross-sectional study was started after the evaluation and approval of the Research Ethics Committee with human beings of the Universidade Federal de São Paulo - Escola Paulista de Medicina (UNIFESP-EPM), protocol 2.179.732. All individuals who agreed to participate in the research were informed about the procedures and signed an Informed Consent Form authorizing their participation in the study and subsequent dissemination of the results. Data were collected from July to December 2017 at the Equilibriometry clinic of the Discipline of Otology and Otoneurology of the Department of Otorhinolaryngology and Head and Neck Surgery at UNIFESP-EPM.

The sample consisted of an experimental group of adults and elderly men and women with a medical diagnosis of DM2, selected through medical records at the Endocrinology and Metabology Clinic and Diabetes Center of the Endocrinology Discipline of UNIFESP-EPM, and by a control group composed of healthy individuals, volunteers from the community, such as patient companions, graduate students, and university professors, with no history of vestibular, visual, neurological or otoneurological symptoms, matched by age and gender.

The inclusion criteria for patients in the experimental group were having a medical diagnosis of DM2 and complaints of vertigo, dizziness, and/or instability. Patients with diabetic polyneuropathy, retinopathy, renal failure, liver failure, heart

failure, and neurological and psychiatric disorders were excluded, according to information from medical records. Through anamnesis, patients with the inability to understand and attend to simple verbal commands, inability to remain independently in the orthostatic position, visual impairment not compensated with the use of corrective lenses, orthopedic disorders with movement limitation or use of lower limb prostheses, use of medications that act on the vestibular system and that have performed body balance rehabilitation in the last six months were also excluded.

Participants underwent a neurotological assessment consisting of anamnesis; otorhinolaryngological examination; Brazilian version of the Dizziness Handicap Inventory (DHI)[13]; the visual analog scale of vertigo and dizziness[14]; and posturography of *BRU™*, Medicaa, Uruguai.

The DHI was used to assess the self-perception of disability caused by vestibular symptoms in quality of life. The DHI consists of 25 questions, seven on the physical aspects, nine on the emotional, and nine on the functional. The questions were presented verbally by the evaluator; in each question, the participants answered yes, sometimes, or not, corresponding to 4, 2, or zero points, respectively. The total score ranged from 0 to 100 points, with a maximum score for questions of the physical aspect of 28 points; for the emotional aspect, 36 points; and for the functional aspect, 36 points[13]. DHI scores between 0-30 were classified as mild, 31-60 as moderate, and 61-100, as severe[15].

The visual analog scale of vertigo and dizziness was used to assess the intensity of these symptoms, according to the weighting and classification of the individual in regarding the severity of his feeling of dizziness, scoring, in a ruler, from 0 to 10, with 0 (zero) being the lowest level of dizziness and 10 (ten), the highest[14]. Intensity scores between 0-3 were classified as mild, 4-6 as moderate, and 7-10, severe[16].

BRU™ posturography (Figure 1) was performed in a quiet room of approximately six square meters, with reduced lighting. The equipment includes a computer with the evaluation program, a metal structure with protective support with handles and a safety belt, a powerful platform, virtual reality goggles, an accelerometer, and a foam pad. The 40 cm x 40 cm platform is marked by vertical and horizontal coordinates; it has an 8 cm horizontal line (intermalleolar line) for positioning the feet and a 12 cm vertical line, which intersects the midpoint the intermalleolar line.

Figure 1 - *BRU™ Posturography*

The evaluation was performed with the participant in an orthostatic position and arms extended along the body. The participant was asked to stand on the platform, barefoot, with the right and left inner malleoli positioned at the ends of the intermalleolar line. The internal malleoli were marked with a black pen, and a ruler aided the alignment. The midpoint of the intermalleolar line determined the center of the standard limit of the stability circle. The anterior part of each foot was 10º away from the midline, forming an angle of 20º between the first two toes. For the participants to adopt this position with their feet, a cardboard template was used.

The *BRU™* posturography balance platform converted the pressure applied on the platform into electrical signals and determined the area of the pressure center using quantitative indicators: area of stability limit, area of displacement of the center of pressure, and oscillation speed in ten sensory conditions. The area of the stability limit was measured by approximating the oscillation pattern of an ellipse, using the maximum and minimum total displacements to the right and

the left. The pressure center area was defined as the distribution area of 95% of the pressure center samples; and the average oscillation speed was determined by the total distance covered by the center of pressure and divided by the time of 60 seconds of the test[17].

To determine the stability limit, the participant was instructed to perform maximum antero-posterior and lateral-lateral body movements using the ankle strategy, without moving the feet and without using trunk strategies.

To evaluate area of the center of pressure and the speed of oscillation, the patient was instructed to remain standing, in a stable position, for 60 seconds, without moving upper limbs and heels in ten sensory conditions: 1) orthostatic position on firm ground, eyes open; 2) orthostatic position on firm ground, eyes closed; 3) orthostatic position on foam, eyes closed; 4) orthostatic position on a firm floor, saccadic stimulation; 5) orthostatic position on firm ground, optokinetic stimulation, horizontal direction (from left to right); 6) orthostatic position on firm ground, optokinetic stimulation, horizontal direction (from right to left); 7) orthostatic position on firm ground, optokinetic stimulation, vertical direction (from top to bottom); 8) orthostatic position on firm ground, optokinetic stimulation, vertical direction (from bottom to top); 9) orthostatic position on firm ground, horizontal direction optokinetic stimulation associated with slow head rotation movements; 10) orthostatic position on firm ground, optokinetic stimulation, vertical direction associated with slow head flexion-extension movements(17). From the fourth to the tenth condition, virtual reality glasses and a blindfold were used, and only in the third condition, a medium density foam was used. The individual could wear corrective lenses, if they were used regularly, except under conditions with virtual reality glasses. The software provided visual foveal stimuli (slow and saccadic eye chase) and retinal stimuli (optokinetic bars) and sensory integration stimuli (vestibule-ocular reflex with or without suppression and vestibular optokinetic).

During the procedure, time intervals were provided for the participant to rest, according to his need. Safety, regarding the risk of a possible fall, was guaranteed by the presence of two examiners close to the individuals.

The program stored, calculated, and produced reports with data related to the area of the stability limit and the displacement area of the 95% confidence center of pressure and oscillation speed in the ten sensory conditions.

All data were submitted to descriptive statistical analysis to characterize the sample. The Student's t-test for independent samples analyzed the equality of variances concerning age, and the chi-square test to analyze the homogeneity of the genders between the control and experimental groups. The Shapiro-Wilk test was applied to verify the normality of the variables. In the comparative analysis of the experimental and control groups, the Mann-Whitney non-parametric test was used for the displacement area of the pressure center, in all the sensory conditions evaluated, and as for the speed of oscillation in nine of the ten sensory conditions; in the condition of vestibular-visual interaction, in the vertical direction, Student's t-test was used for independent samples. The data were presented as mean ± standard deviation, median, and minimum and maximum values. The level of significance adopted was $p < 0.05$. The calculations were performed using *IBM SPSS Statistics*, version 23.0.

RESULTS

We evaluated 42 individuals, 20 from the experimental group, 15 females (75%) and five (25%) males; and 22 in the control group, 13 (59.1%) were female and seven (40.9%) were male. The group with DM2 had a mean age of 66.0 + 8.5 years old (x + SD); the control group had a mean age of 67.7 + 9.5 years old. The groups were homogeneous in their genders ($p = 0.275$) and age ($p = 0.551$). The average estimated time for DM2 was 15.3 years.

Table 1 shows the descriptive values of the DHI variables and the visual analog scale of vertigo and dizziness for the experimental group. Thirteen diabetics (65%) presented mild impairment, six (30%) moderate, and one (5%) severe to DHI; the total score characterized the moderate impairment in quality of life. Eleven diabetics (55%) scored on the visual analog scale for vertigo and dizziness classified as severe, five (25%) as moderate, and four (20%) as mild; the average of 6.45 points characterized the intensity of the symptoms as moderate.

Table 2 shows the descriptive values and comparative analysis of the area of the stability limit of the experimental group and the control group in the *BRU*™ static posturography. There was a statistically significant difference between the groups. The values of the stability limit area of the experimental group were significantly lower than those in the control group ($p = 0.045$).

Table 3 shows the descriptive values and comparative analysis of the displacement area of the pressure center (cm2) of the experimental group and the control group in the ten conditions of the *BRU*™ static posturography. The mean values of the displacement area of the pressure center of the experimental group were higher than those of the control group in all conditions evaluated, with a statistically significant difference in conditions on a firm surface with eyes open, on a firm surface with eyes closed and on firm surface with visuovestibular interaction in the horizontal direction of cephalic movement.

Table 4 shows the descriptive values and comparative analysis of the oscillation speed (cm/s) of the experimental group and the control group in the ten conditions of *BRU*™ static posturography. The experimental group presented an average oscillation speed value higher than the control group in most of the evaluated conditions, except for the conditions on the foam with closed eyes and of visuovestibular interaction in the vertical direction of cephalic movement, with a statistically significant difference in conditions on a firm surface, with eyes open and eyes closed.

Table 1. Descriptive values of the Dizziness Handicap Inventory questionnaire, the visual analog scale of vertigo and dizziness, and the duration of illness of 20 type 2 diabetics with vertigo, dizziness, and/or instability

Variable	Average	Standard deviation	Mean	Minimum value	Maximum value
DHI (points)	31.30	21.51	27.00	6.00	90.00
EVA (points)	6.45	2.82	7.00	1.00	10.00
Disease duration (months)	183.75	184.15	144	7.00	756.00

Captions: *DHI: Dizziness Handicap Inventory*; EVA: the visual analog scale of vertigo and dizziness

Table 2. Descriptive values and comparative analysis of the stability limit of 20 type 2 diabetics with vertigo, dizziness, and/or instability and of 22 healthy individuals from the control group in the static posturography of the *Balance Rehabilitation Unit (BRU™)*

	Groups	Average	Standard deviation	Mean	Minimum value	Maximum value	p-value
SL	Control	160.00	52.93	156.50	83.00	274.00	0.045*
	Diabetes	126.00	53.38	120.00	19.00	228.00	

Captions: SL: stability limit; Student's t-test for independent samples; * Statistically significant value at the 5% level ($p < 0.05$)

Table 3. Descriptive values and comparative analysis of the displacement of the pressure center (cm^2) of 20 type 2 diabetics with vertigo, dizziness, and/or instability and 22 healthy individuals from the control group in the ten sensory conditions of the static posturography of the *Balance Rehabilitation Unit (BRU™)*

Area of pressure center displacement	Groups	Average	Standard deviation	Mean	Minimum value	Maximum value	p-value
FS/Open eyes							
No stimuli	Control	1.96	1.56	1.62	0.34	7.20	0.023*[a]
	Diabetes	3.39	2.89	2.77	0.75	11.63	
FS/Closed eyes	Control	1.61	1.24	1.23	0.32	5.83	0.007*[a]
	Diabetes	4.65	6.59	2.51	0.66	29.87	
Foam/Closed eyes	Control	8.28	4.28	7.32	2.90	17.58	0.650[a]
	Diabetes	9.98	7.11	7.88	2.87	30.73	
FS/Saccadic	Control	2.31	2.21	1.70	0.70	11.19	0.074[a]
	Diabetes	3.51	2.68	2.52	0.77	11.10	
FS/Bars/Optokinetic to the right	Control	2.49	2.58	2.10	0.57	13.14	0.406[a]
	Diabetes	3.64	4.37	1.88	0.88	20.51	
FS/Bars/Optokinetic to the left	Control	2.58	2.18	2.37	0.30	10.54	0.734[a]
	Diabetes	3.85	5.28	2.46	0.55	22.77	
FS/Bars/Optokinetic downwards	Control	2.39	1.79	2.17	0.41	8.81	0.597[a]
	Diabetes	3.80	4.48	2.09	0.64	19.55	
FS/Bars/Upwards Optokinetic	Control	2.39	1.86	1.99	0.37	7.58	0.513[a]
	Diabetes	3.35	3.77	2.23	0.68	15.68	
FS/visuovestibular interaction/Horizontal	Control	2.80	1.76	2.20	0.58	6.59	0.047*[a]
	Diabetes	5.60	6.42	3.99	1.22	29.02	
FS/visuovestibular interaction/Vertical	Control	3.70	2.42	3.28	0.69	10.18	0.203[a]
	Diabetes	5.20	4.69	4.31	1.18	23.01	

Captions: FS: hard surface; [a]: Mann-Whitney U test; * Statistically significant value at the 5% level ($p < 0.05$)

Table 4. Descriptive values and comparative analysis of the oscillation speed (cm/s) of 20 type 2 diabetic individuals with vertigo, dizziness, and/or imbalance and 22 healthy individuals in the control group in the ten sensory conditions of the static posturography of the *Balance Rehabilitation Unit (BRU™)*

Oscillation Speed (cm/s)	Groups	Average	Standard deviation	Mean	Minimum value	Maximum value	p-value
FS/Open eyes							
No stimuli	Control	0.81	0.26	0.76	0.50	1.36	0.039*[a]
	Diabetes	0.95	0.28	0.88	0.54	1.64	
FS/Closed eyes	Control	0.96	0.35	0.87	0.60	2.00	0.020*[a]
	Diabetes	1.27	0.48	1.21	0.53	2.47	
Foam/Closed eyes	Control	2.53	0.62	2.37	1.56	3.82	0.513[a]
	Diabetes	2.48	0.80	2.32	1.46	4.57	
FS/Saccadic	Control	1.13	0.53	0.92	0.57	2.96	0.068[a]
	Diabetes	1.29	0.36	1.26	0.67	2.12	
FS/Bars/Optokinetic to the right	Control	1.15	0.53	0.95	0.58	2.77	0.247[a]
	Diabetes	1.20	0.41	1.09	0.66	2.57	
FS/Bars/Optokinetic to the left	Control	1.11	0.52	0.93	0.44	2.35	0.231[a]
	Diabetes	1.21	0.51	1.09	0.60	2.71	
FS/Bars/Optokinetic downwards	Control	1.07	0.46	0.93	0.44	2.02	0.066[a]
	Diabetes	1.28	0.50	1.23	0.62	2.79	
FS/Bars/Upwards Optokinetic	Control	1.06	0.43	0.92	0.48	2.23	0.158[a]
	Diabetes	1.19	0.51	1.06	0.58	2.76	
FS/visuovestibular interaction/Horizontal	Control	1.47	0.68	1.28	0.58	3.41	0.406[a]
	Diabetes	1.50	0.53	1.38	0.71	2.92	
FS/visuovestibular interaction/Vertical	Control	1.63	0.66	1.52	0.66	3.38	0.118[b]
	Diabetes	1.52	0.43	1.48	0.74	2.42	

Captions: SF: firm surface; [a] Mann-Whitney U test; [b] Student's t-test for independent samples; * Statistically significant value at the 5% level ($p < 0.05$)

DISCUSSION

The findings in the *BRU™* static posturography of the experimental group with DM2 with vertigo, dizziness, and/or instability were compared with those of the control group. Few articles were found that compared the posturographic findings of individuals with DM2 without polyneuropathy with healthy individuals. In addition, the quantitative comparison of the results with those of other posturographs is limited due to the differences between the procedures and evaluation parameters.

There was a prevalence of females (75%) over males (25%) in individuals with DM2 and complaints of dizziness and/or vertigo, as occurred in some diabetes prevalence studies[18,19], while others observed no difference between genders[20,21]. In addition, dizziness is more prevalent in women than in men[22,24]. The predominance in females can be justified by variations in the hormonal cycle, which predisposes and causes metabolic changes[21,24], and the fact that women seek more medical care than men[24].

The mean age of the group with DM2 and vertigo, dizziness, and/or instability was 66 years old. Dizziness[22,23] and Diabetes[19,21] are more frequent with advancing age.

The application of Brazilian DHI showed moderate impairment in the quality of life of individuals with DM2, like another study[25].

The visual analog scale of vertigo and dizziness indicated a moderate degree of intensity of vestibular symptoms. No studies were found that applied the visual analog scale of vertigo and dizziness in individuals with DM2.

The area of the stability limit of the DM2 group was smaller than in the control group, demonstrating less ability to move the center of body mass and maintain balance. We found no citations on the literature about the limit of stability in type 2 diabetes at *BRU™* posturography. When assessing the stability limit using another posturography, individuals with DM2 also performed worse than the control group, with higher oscillation values and with less weight displacement on the platform[26].

The DM2 group presented oscillation speed value higher than the control group in most of the evaluated conditions, except for the conditions on the foam with closed eyes and of visuovestibular interaction in the vertical direction of cephalic movement, with a statistically significant difference in conditions on a firm surface, with eyes open and eyes closed. The mean values of the displacement area of the pressure center of the DM2 group were higher than those of the control group in all conditions evaluated, with a statistically significant difference in conditions on a firm surface with eyes open, on a firm surface with eyes closed and on firm condition with visuovestibular interaction in the horizontal

direction of cephalic movement. These data show impairment in static balance in conditions with or without deprivation of vision and with visual conflict, through stimuli that integrate the visual and vestibular systems. Both groups oscillated similarly in the condition with the eyes closed and on the foam. Difficulty standing with their eyes closed on an unstable surface was also observed in 32% of individuals aged 40 or over with no history of dizziness[5] and in a control group of healthy volunteers in *Tetrax*^{TM}[27], corroborating the result of the present research. Individuals with DM2 did not show a reduction in postural control in the sensory condition in which there is a disturbance of proprioceptive information or the *BRU*^{TM} posturography was not sensitive to identify changes in this condition. No citations were found in the literature about changes in the oscillation speed and the area of displacement of the pressure center in DM2 at *BRU*^{TM} posturography.

The findings of other static posturographs showed that the group with DM2 oscillated significantly more than the group of healthy individuals with closed eyes[26], on a firm surface with eyes closed with the head tilted 30° degrees back, with the rotation of 45° degrees to the right and 45° degrees to the left[28], eyes open and closed, and with visuovestibular conflict, on a firm surface, and on a pillow[29]. The area and oscillation speeds of the DM2 group were greater than in the control, with eyes open and closed on the foam, but with a significant difference only with eyes open; in both groups, postural sway increased with an unstable surface and/or closed eyes[12]. However, another study found no significant difference between the group of individuals with DM without polyneuropathy and the control group concerning the area and speed of postural sway[30].

The small sample size was the main limitation of this study since most patients interviewed at the Endocrinology and Metabolology Outpatient Clinic and Diabetes Center of the Endocrinology Discipline at UNIFESP-EPM had no vertigo, dizziness, and/or instability. Among the individuals who presented these symptoms, many were not included in the sample due to the comorbidities that were included in the exclusion criteria. Even so, we identified significant changes in postural control in DM2 in the *BRU*^{TM} posturography than in the control group.

Further research is needed, considering the comparison between DM2 with and without polyneuropathy, associated or not with vestibular symptoms; the use of other neurotological assessment instruments, in addition to static posturography, DHI, and visual analog scale of vertigo and dizziness, it may contribute to assess the development of vestibular damage and its influence on postural control.

In this research, *BRU*^{TM} posturography proved to be a method that helps to identify changes in sensory systems related to the body balance of individuals with DM2 with vertigo, dizziness, and/or instability, providing information about the stability limit, the oscillation speed, and the displacement area of the pressure center in situations with or without visual, somatosensory or vestibular deprivation and visuovestibular interaction. The characterization of the postural control disorder in each patient with this condition can contribute in a relevant way in the scheduling of vestibular rehabilitation procedures, in the monitoring of the pertinent treatment, and even in prevention, aiming at the resolution or mitigation of vertigo, dizziness or instability and in the elimination or reduction of the risk of falls.

CONCLUSION

Individuals with DM2 and vertigo, dizziness, and/or instability have impaired postural balance related to visual stimuli and visuovestibular interaction and moderate impairment in quality of life.

REFERENCES

1. Oliveira JEP, Venâncio S. Diretrizes da Sociedade Brasileira de Diabetes. São Paulo: A.C. Farmacêutica; 2016.
2. International Diabetes Federation. IDF Diabetes Atlas [Internet]. 8a ed. Brussels: International Diabetes Federation, 2017. Available in: https://www.diabetesatlas.org/upload/resources/2019/IDF_Atlas_9th_Edition_2019.pdf.
3. Cade WT. Diabetes-related microvascular and macrovascular diseases in the physical therapy setting. Phys Ther. 2008;88:1322-35. PMid: 18801863. PMCID: PMC2579903. DOI: 10.2522/ptj.20080008.
4. Agrawal Y, Carey JP, Della Santina CC, Schubert MC, Minor LB. Disorders of balance and vestibular function in US adults: data from the National Health and Nutrition Examination Survey, 2001-2004. Arch Intern Med. 2009;169:938-44. PMid: 19468085. DOI: 10.1001/archinternmed.2009.66.
5. Perez R, Ziv E, Freeman S, Sichel JY, Sohmer H. Vestibular end-organ impairment in an animal model of type 2 diabetes mellitus. Laryngoscope. 2001;111:110-3. PMid: 11192877. DOI: 10.1097/00005537-200101000-00019.
6. Ferreira Junior CA, Guimarães RES, Becker HMG, Silva CD, Gonçalves TML, Crosara PFTB, et al. Avaliação metabólica do paciente com labirintopatia. Arq Otorrinolaringol. 2000;4:28-32.
7. Agrawal Y, Carey JP, Della Santina CC, Schubert MC, Minor LB. Diabetes, vestibular dysfunction, and falls: analyses from the National Health and Nutrition Examination Survey. Otol Neurotol. 2010;31:1445-50. PMid: 20856157. DOI: 10.1097/MAO.0b013e3181f2f035.
8. Walley M, Anderson E, Pippen MW, Maitland G. Dizziness and loss of balance in individuals with diabetes: Relative contribution of vestibular versus somatosensory dysfunction. Clin Diabetes. 2014;32:76-7. PMid: 26130865. PMCID: PMC4485245. DOI: 10.2337/diaclin.32.2.76.
9. Schubert MC, Minor LB. Vestibulo-ocular physiology underlying vestibular hypofunction. Phys Ther. 2004;84:373-85. PMid: 26130866. PMCID: PMC4485245. DOI: 10.2337/diaclin.32.2.76.
10. Crews RT, Yalla SV, Fleischer AE, Wu SC. A growing troubling triad: diabetes, aging, and falls. J Aging Res. 2013;2013:342650. PMid: 23476773. PMCID: PMC3586503. DOI: 10.1155/2013/342650.
11. Duarte M, Freitas SMSF. Revisão sobre posturografia baseada em plataforma de força para avaliação do equilíbrio. Rev Bras Fisioter. 2010;14:183-92. https://doi.org/10.1590/S1413-35552010000300003.
12. Abdul Razzak R, Hussein W. Postural visual dependence in asymptomatic type 2 diabetic patients without peripheral neuropathy during a postural challenging task. J Diabetes Complications. 2016;30:501-6. PMid: 26774792. DOI: 10.1016/j.jdiacomp.2015.12.016.
13. Castro ASO, Natour J, Gazzola JM, Ganança FF. Dizziness Handicap Inventory: adaptação cultural para o português brasileiro. Pró-Fono R Atual Cient. 2007;19:97-104. http://dx.doi.org/10.1590/S0104-56872007000100011.
14. Whitney SL, Herdman SJ. Physical therapy assessment of vestibular hypofunction. In: Herdman SJ. Vestibular rehabilitation. Philadelphia: FA. Davis; 2000. p. 336. PMid: 26913496. PMCID: PMC4795094. DOI: 10.1097/NPT.0000000000000120.
15. Whitney SL, Wrisley DM, Brown KE, Furman JM. Is perception of handicap related to functional performance in persons with vestibular

dysfunction? Otol Neurotol. 2004;25(2):139-43. PMid: 15021773. DOI: 10.1097/00129492-200403000-00010.

16. Grigol TA, Silva AM, Ferreira MM, Manso A, Ganança MM, Caovilla HH. Dizziness handicap inventory and visual vertigo analog scale in vestibular dysfunction. Int Arch Otorhinolaryngol. 2016 Jul;20(3):241-3. https://doi.org/10.1055/s-0035-1567808.
17. BRUTM. Unidade de Reabilitação do Equilíbrio. Manual do usuário. Versão 1.0.7. versão do software: 1.3.5.0. Uruguai: Medicaa; 2006. 132p.
18. Fidelis LC, Moreira OC, Teodoro BG, Oliveira CEP. Prevalência de diabetes mellitus no município de Teixeiras - MG. Rev Bras Ativ Fis Saúde. 2009;14:23- 7.
19. Silva DS, Laterza MC, Moreira OC, Carneiro MA, Amorim PRS. Prevalência de diabetes mellitus em indivíduos atendidos pela estratégia saúde da família no município de Ubá-MG. Rev Bras Ativ Fis Saúde. 2012;17:195-99.
20. Goldenberg P, Schekman S, Franco LJ. Prevalência de diabetes mellitus: diferenças de gênero e igualdade entre os sexos. Rev Bras Epidemiol. 2003;6:18-28. https://doi.org/10.1590/S1415-790X2003000100004.
21. Souza LJ, Chalita FEB, Reis AFF, Teixeira CL, Neto CG, Bastos DA, et al. Prevalência de diabetes mellitus e fatores de risco em Campos dos Goytacazes, RJ. Arq Bras Endocrinol Metab. 2003;47:69-74. https://doi.org/10.1590/S0004-27302003000100011.
22. Yardley L, Owen N, Nazareth I, Luxon L. Prevalence and presentation of dizziness in a general practice community sample of working age people. Br J Gen Pract. 1998;48:1131-5. PMid: 9667086. PMCID: PMC1410052.
23. Hannaford PC, Simpson JA, Bisset AF, Davis A, McKerrow W, Mills R. The prevalence of ear, nose and throat problems in the community: results from a national cross-sectional postal survey in Scotland. Fam Pract. 2005;22:227-33. PMid: 15772117. DOI: 10.1093/fampra/cmi004.
24. Bittar RSM, Oiticica J, Bottino MA, Ganança FF, Dimitrov R. Population epidemiological study on the prevalence of dizziness in the city of São Paulo. Braz J Otorhinolaryngol. 2013;79:688-98. https://doi.org/10.5935/1808-8694.20130127.
25. Aranda C, Meza A, Rodríguez R, Mantilla MT, Jáuregui-Renaud K. Diabetic polyneuropathy may increase the handicap related to vestibular disease. Arch Med Res. 2009;40:180-5. PMid: 19427968. DOI: 10.1016/j.arcmed.2009.02.011.
26. Petrofsky JS, Cuneo M, Lee S, Johnson E, Lohman E. Correlation between gait and balance in people with and without type 2 diabetes in normal and subdued light. Med Sci Monit. 2006;12:CR273-81. PMid: 16810132.
27. Gorski LP, Silva AM, Cusin FS, Cesaroni S, Ganança MM, Caovilla HH. Equilíbrio corporal à posturografia estática na migrânea vestibular. Braz J Otorhinolaryngol. 2017. pii: S1808-8694(17)30218-5. DOI: 10.1016/j.bjorl.2017.12.001. [Epub ahead of print].
28. Oppenheim U, Kohen-Raz R, Alex D, Kohen-Raz A, Azarya M. Postural characteristics of diabetic neuropathy. Diabetes Care. 1999;22:328-32. PMid: 10333953. DOI: 10.2337/diacare.22.2.328.
29. Nicholson M, King J, Smith PF, Darlington CL. Vestibulo-ocular, optokinetic and postural function in diabetes mellitus. Neuroreport. 2002;13:153-7. PMid: 11924879. DOI: 10.1097/00001756-200201210-00035.
30. Yamamoto R, Kinoshita T, Momoki T, Arai T, Okamura A, Hirao K, et al. Postural sway and diabetic peripheral neuropathy. Diabetes Res Clin Pract. 2001;52:21. PMid: 26831420. PMCID: PMC4774068. DOI: 10.4103/0971-5916.174562.

Authors' contributions

JYF participated in the conception and design of the study, data collection, analysis and interpretation, writing and revising the article in an intellectually important way and final approval of the version to be published; RMQ participated in the study idealization, data collection and analysis, review of the article in an intellectually important way and final approval of the version to be published; SAD participated in the selection of the sample, analysis and interpretation of data, review of the article in an intellectually important way and final approval of the version to be published; MMG participated in the conception and design of the study, data analysis and interpretation, writing and revising the article in an intellectually important way and final approval of the version to be published; HHC participated as a supervisor, in the idealization and design of the study, analysis, data interpretation, writing and revision of the article in an intellectually important way and final approval of the version to be published.