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Video head impulse test (v-hit) in individuals with type 1 diabetes mellitus

Video head impulse test (v-hit) em indivíduos com diabetes mellitus tipo 1

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ABSTRACT

Purpose: To verify the function of the labyrinth semicircular channels of type 1 diabetes individuals submitted to the Video Head Impulse Test (v-HIT) and to compare them with individuals without diabetes. **Methods:** Cross-sectional, observational, analytical study conducted with a convenience sample of 35 diabetic and 100 non-diabetic individuals. All participants were submitted to vestibular evaluation using v-HIT. **Results:** The sample consisted of 135 participants divided into two groups. The study group was composed of individuals with type 1 diabetes, totaling 21 women and 14 men. The age range was between 18 and 71 years, with a mean of 35.37 years and standard deviation of 10.98. The group without diabetes was composed of 77 women and 23 men. The age range was between 20 to 83 years, with a mean of 46.44 and standard deviation of 19.82. The groups were matched for age (p=0.098) and gender (p=0.052). Diabetic patients showed decreased gain in the posterior and left anterior semicircular canals. Velocity showed a significant difference in the left lateral, anterior right and posterior left canals in the group with DM1, however velocity did not show correlation with the gain of the semicircular canals. **Conclusion:** participants with type 1 diabetes mellitus showed a decreased gain in the posterior semicircular canals and in the left anterior canal when compared to non-diabetic individuals.

Keywords: Inner ear; Semicircular canals; Labyrinth diseases; Diabetes mellitus; Postural balance

RESUMO

Objetivo: Verificar a função dos canais semicirculares do labirinto de indivíduos com diabetes tipo 1, submetidos ao *Video Head Impulse Test* (v-HIT), e compará-los com indivíduos sem diabetes. **Métodos:** Estudo transversal, observacional, analítico, realizado com uma amostra de conveniência, formada por 35 indivíduos diabéticos e 100 não diabéticos. Todos os participantes foram submetidos à avaliação vestibular por meio do v-HIT. **Resultados:** A casuística foi composta por 135 participantes, divididos em dois grupos. O grupo de estudo foi composto por indivíduos com diabetes tipo 1, totalizando 21 mulheres e 14 homens. A idade variou entre 18 e 71 anos, com média de 35,37 anos e desvio padrão de 10,98. O grupo sem diabetes foi composto por 77 mulheres e 23 homens. A idade variou entre 20 e 83 anos, com média de 46,44 e desvio padrão de 19,82. Os grupos foram pareados entre si, com relação à idade (p=0,098) e sexo (p=0,052). Os pacientes diabéticos apresentaram ganho diminuído nos canais semicirculares posteriores e anterior esquerdo. A velocidade apresentou diferença significativa nos canais lateral esquerdo, anterior direito e posterior esquerdo no grupo com diabetes mellitus tipo 1, porém não apresentou correlação com o ganho dos canais semicirculares. **Conclusão:** Os participantes com diabetes mellitus tipo 1 apresentaram um ganho diminuído nos canais semicirculares posteriores e no canal anterior esquerdo quando comparados com indivíduos não diabéticos.

Palavras-chave: Orelha interna; Canais semicirculares; Doenças do labirinto; Diabetes mellitus; Equilíbrio postural

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INTRODUCTION

Type 1 Diabetes Mellitus (DM1) is an autoimmune disease, characterized by the progressive loss of beta-pancreatic cells, which causes the interruption of insulin production and, consequently, a severe metabolic imbalance[1,2]. The International Diabetes Federation (IDF) reveals that, every year, more than 70 thousand people develop DM1, in Brazil[3-5].

It is estimated that more than 30 thousand Brazilians are affected by DM1 and that Brazil occupies the third position in the prevalence of DM1 in the world, according to the IDF[6,7]. Although the disease prevalence is increasing, DM1 corresponds to only 5% to 10% of all cases of DM. The disease is frequently diagnosed in children, adolescents and, in some cases, in young adults, affecting equally men and women[8,9].

There are reports that carbohydrate metabolism disorders can affect the functioning of the vestibular apparatus[10,11]. The most frequent vestibulopathies include benign paroxysmal positional vertigo (BPPV), endolymphatic hydrops and vestibulopathies of metabolic origin, which are responsible for 17.1% of labyrinth disorders[12,13]. Several metabolic changes in carbohydrates can affect the functioning of the vestibular and auditory systems, most of them due to glucose metabolism disorders[13].

Glucose metabolism provides the energy necessary for the maintenance of the difference in endolymphatic and perilymphatic potential and the difference in neuronal transmembrane potential, which will allow peripheral information to reach the central nervous system and be properly processed[14].

In the vestibular assessment of individuals with glucose metabolism disorder, electronystagmographic changes were found in 27.1% to 43.8% of the individuals[15]. One study identified changes in the insulinemic curve in patients with vestibular disorders when compared to healthy volunteers, with a statistically significant difference[16]. Other studies have demonstrated vestibular changes in asymptomatic diabetic individuals[10]. These findings reveal the importance of performing a peripheral vestibular assessment in individuals with diabetes.

The semicircular canals (SC) detect angular movements of the head, through the vestibulo-ocular reflex (VOR), while the saccule and utricle detect the linear accelerations of the head, in addition to head-tilts in space[17-20]. The VOR is responsible for maintaining a clear image on the retina during head movements, triggering compensatory eye movements in the opposite direction[20,21]. Previous studies used the caloric test to assess the vestibular function of individuals with diabetes mellitus, but, currently, this analysis can be performed in an objective and detailed way, through the assessment of the vestibulo-ocular reflex using the Video Head Impulse Test (v -HIT)[22-25].

The v-HIT is a fast and objective exam, which evaluates the VOR in each semicircular canal, individually, and in physiological frequency of the angular acceleration of the head, by means of fast and short amplitude cephalic impulses. With each impulse, v-HIT records the head movements and the reflex response of the eye. Impulsive tests are fast in triggering VOR without cortical contamination or slow eye systems, assessing the vestibular function at higher frequencies than caloric testing[22-24].

Several studies have highlighted the practicality and objectivity of v-HIT, which is able to accurately locate the affected semicircular canal, confirming the clinical usefulness of this exam in the diagnosis and monitoring of the individuals with otoneurological disorders rehabilitation[17-19,22-24]. Furthermore, v-HIT is an exam that does not cause discomfort to the patient and does not need any prior preparation for its performance.

v-HIT studies evaluating the vestibular function of individuals with DM1 are still scarce in the literature. There are studies in this population using only vectoelectronystagmography[10,15,16]. Given the above, the objective of this study was to evaluate the vestibular function of individuals with type 1 diabetes mellitus, using v-HIT, and to compare the results with those obtained in individuals without diabetes.

METHOD

The procedures for this investigation were approved by the Ethics Committee of the Federal University of Minas Gerais State (UFMG), under CAAE nº 56877316.1.0000.5149. The investigation was carried out at the Observatory of Functional Health in the Speech Therapy Department of the School of Medicine, Federal University of Minas Gerais State - UFMG - Minas Gerais (MG), Brazil.

The sample consisted of 135 participants answering a questionnaire, reporting no complaints of dizziness, divided into two groups. The study group was composed of individuals with DM1, totaling 21 women and 14 men. Age varied between 18 and 71 years, with a mean of 35.37 years and standard deviation of 10.98. The control group was composed of 77 women and 23 men without diabetes. Age ranged between 20 and 83 years, with a mean age of 46.44 and standard deviation of 19.82. The groups were matched for age (p=0.098) and gender (p=0.052).

In the group without diabetes, individuals over 18 years of age who voluntarily agreed to participate in the investigation, who exhibited normal otoscopy, with no history of surgery or otological trauma, without previous self-reported vestibular diseases, with no cervical movement difficulties and who signed the Free and Informed Consent Form were included. In addition to the items mentioned above, participants with DM1, were submitted to auditory assessment (immittance and audiometry). The individuals in the group without diabetes were recruited in the academic community (students, professors and university staff) and the individuals with diabetes were recruited in the Endocrinology Clinic at *Universidade Federal de Minas Gerais* (UFMG), where the investigation took place. DM1 participants were being monitored for glycemic control and the duration of the disease ranged from seven months to 46 years, with a mean of 21.9 years and a standard deviation of 10.2.

The individuals were informed about the investigation objectives, the investigation risks and benefits, and those who voluntarily agreed to participate were then scheduled to come back on the day and time they would be available. Initially, each participant answered a questionnaire covering demographic information (age and gender) and data related to ear and vestibular history. Patients with DM1 answered a specific questionnaire, which contained, in addition to the demographic questions (age and gender), other questions related to otological and vestibular history, besides information about DM1. All the screening exams were performed by the same investigator.

The demographic variables reviewed in this study were age and gender. The v-HIT results were assessed with respect to gain and the presence of corrective saccades. The velocity of the impulses applied was measured as a way to ensure the proper execution of the movements. No other otoneurological exam was performed and all participants denied dizziness/vertigo in their answers to the questionnaire.

For the auditory assessment of the participants with DM1, meatoscopy and audiometry tests were performed in an acoustically treated room. For tympanometry, the Otoflex 100 Otometrics® equipment was used and the patient was instructed to remain seated, in silence, and a probe was then introduced in the external auditory canal of each ear to capture responses. The audiometry was performed using the Itera II Otometrics® equipment, with the patient sitting with his back to the device and the evaluator, in silence, with the Sennheiser HDA-200 headset, properly positioned. Hearing assessment was performed as a way to rule out hearing loss that could be associated to previous diseases of the inner ear[12].

For the v-HIT, the Otometrics® ICS-impulse® equipment was used. The participants remained seated on a chair 120 cm from the target, positioned at eye level, with the goggle device's straps tight adjusted to the head, in order to minimize possible goggle slips. After calibrating the eye position signal, the subject was instructed to stare at a target located on the wall, while the examiner performed cephalic impulses on the specific stimulation planes of the six SC. At least 20 impulses were obtained in each cephalic movement plane, with a maximum of 10 impulses rejected as inappropriate by the equipment›s software. The v-HIT was repeated when there was hypofunction in any semicircular canal, in order to confirm the result obtained

To assess the lateral canals, short and rapid movements to the right and left with the participant's head were made at random. In the assessment of the vertical canals, the participant's head was moved 45 ° to the right of the median plane of the head, placing the left anterior and right posterior canals (LARP) to the stimulation plane. In this position, a forward motion of the head activates the left anterior canal and a backward movement activates the right posterior canal. Then, the participant's head was positioned at this same angle to the left, evaluating the synergistic pair of right anterior and left posterior SC (RALP). In this position, the head forward movement stimulates the right anterior canal and placing the head backwards the left posterior canal is stimulated. Cephalic impulses of unpredictable frequency and direction were generated, characterized by low amplitude (10-20°), high acceleration (1,000-2,500°/s^2) and velocity (100-250°/s), according to the parameters suggested by the user equipment's manual. Other studies have also used these cephalic impulses parameters, as a way to ensure a reliable examination[17-20]. The total duration of the exam was approximately 15 minutes.

The equipment features sensors that detect and record head and eyes movement. For each movement performed by the examiner (impulse), a sinusoid is generated on a chart, which results from the movement of the head and eyes. In normal individuals, the sinusoids are expected to be the same, which results in the so-called gain equal to 1. When the movement of the eyes is slower than the head movement, there is a gain below 1 and the compensatory movement of the eyes - corrective saccade - occurs to bring the eyes back on target. The exam was validated and presents specificity values of 93% and sensitivity of 74%. A gain greater than or equal to 0.8 for the lateral canals and 0.75 for the vertical canals is considered normal[23,24].

The data collected was entered in an Excel program worksheet and analyzed statistically, using the Statistical Package for the Social Sciences (SPSS), version 22.0. Initially, the analysis of the frequency of the variables age and gender, the measures of central tendency (mean and median), dispersion (standard deviation) and position (maximum and minimum) of the variables SC gain and cephalic impulses were performed. The normality of the variables age, gain and cephalic impulse velocity was observed using the Kolmogorov-Smirnov test. The comparison of age and gender variables between groups was performed using the Mann-Whitney and Chi-square tests, respectively. The comparison of the groups with and without diabetes was performed using the Mann-Whitney test, with a significance level of 5% (p <0.05) in all analyses.

RESULTS

The gain values of the six SC can be seen in Table 1. The group with diabetes exhibited a lower gain in the posterior canals, as well as in the left anterior canal

As an illustration, Figures 1 and 2 show images of v-HIT exams of two participants, the first being an individual without diabetes, with gain within normal standards (Figure 1) and the second, a participant with DM1, who showed a reduced gain of the posterior and right anterior SC (Figure 2). Corrective saccades were not observed in any of the groups.

The velocity values applied in the tests are described in Table 2. In the group with diabetes, lower velocity was applied in the left lateral, right anterior and left posterior SC, in comparison with the group without diabetes.

A correlation analysis between the cephalic impulses velocity and the SC gain was performed and it was observed that, only in the right (R-0.357; p-0.001) and left (R-0.26; p-0.010) lateral canal, both in the group without diabetes, the higher the velocity of cephalic impulses, the lower the SC gain. In the group with diabetes, there was no significant correlation between the cephalic impulses velocity and the SC gain.

The association between gender and SC gain in both groups was also analyzed, and statistical significance was found only in the control group for the left anterior SC (p 0.04), with the greatest gain in males, and right posterior SC (p 0,02), with greater gain observed in females.

In this study, the results obtained in each semicircular canal assessed were described, comparing these results between the control groups and those with DM1. We chose not to study the variable symmetry between sides.

DISCUSSION

The two groups studied were statistically matched with respect to age and gender, with the female gender being present in a greater proportion in both groups. The female gender, even being prevalent in both groups, showed only association with the right posterior canal in the group without diabetes. The group without diabetes showed values within the normal range of gain in all SC, as expected for individuals without vestibular disease[17-22].

Most individuals with DM1 had their hearing within the normal range. There was an increase in the occurrence of hearing

Table 1. Analysis of the gain of semicircular canals between the two groups, with and without diabetes

Gain		Diabetes		p-value
		Absent	**Present**	
Left Lateral	Average	0.96	0.97	
	Median	0.93	0.95	0.136
	Minimum	0.64	0.72	
	Maximum	1.42	1.20	
	Standard Deviation	0.13	0.99	
Right Lateral	Average	1.04	1.05	
	Median	1.0	1.0	0.307
	Minimum	0.76	0.57	
	Maximum	1.52	1.43	
	Standard Deviation	0.12	0.14	
Left Anterior	Average	0.95	0.85	
	Median	**0.93**	**0.85**	**<0.001***
	Minimum	0.71	0.51	
	Maximum	1.59	1.18	
	Standard Deviation	0.14	0.14	
Right Anterior	Average	0.89	0.81	
	Median	0.89	0.83	0.054
	Minimum	0.59	0.43	
	Maximum	1.34	1.16	
	Standard Deviation	0.15	0.20	
Right Posterior	Average	0.86	0.73	
	Median	**0.87**	**0.73**	**<0.001***
	Minimum	0.41	0.42	
	Maximum	1.46	1.09	
	Standard Deviation	0.13	0.12	
Left Posterior	Average	0.85	0.71	
	Median	**0.87**	**0.76**	**<0.001***
	Minimum	0.34	0.12	
	Maximum	1.31	1.04	
	Standard Deviation	0.16	0.21	

Mann-Whitney Test *p<0.05

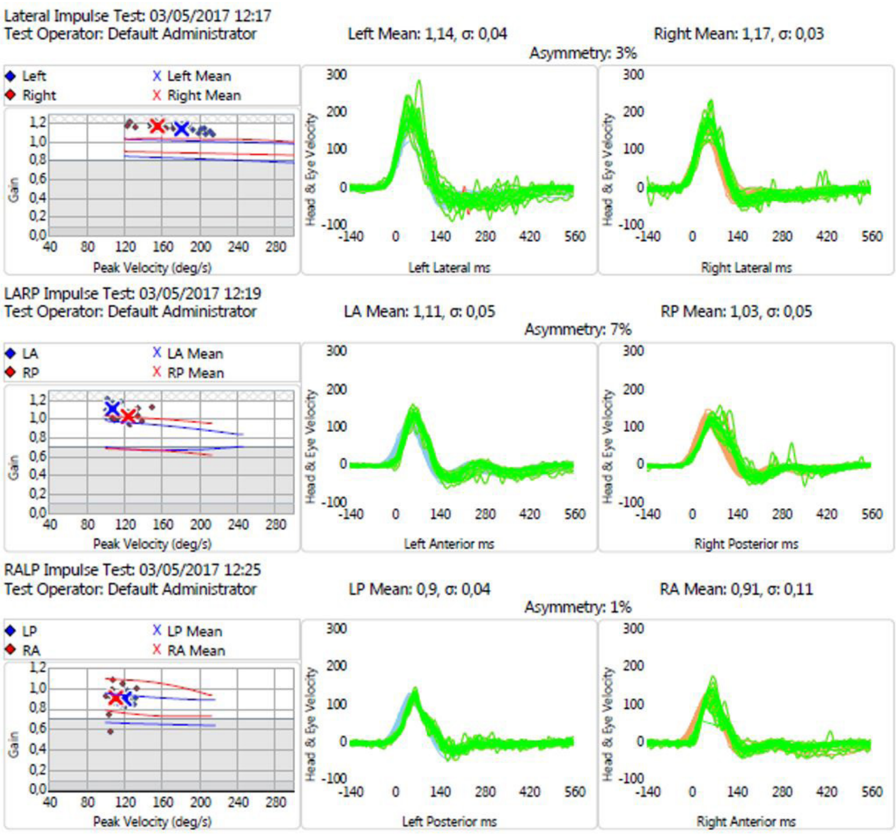

Figure 1. Examination of participant without diabetes
Subtitle: LARP = *left anterior and right posterior*; LA = *left anterior*; RP = *right posterior*; RALP = *right anterior and left posterior*; RA = *right anterior*; LP = *left posterior*

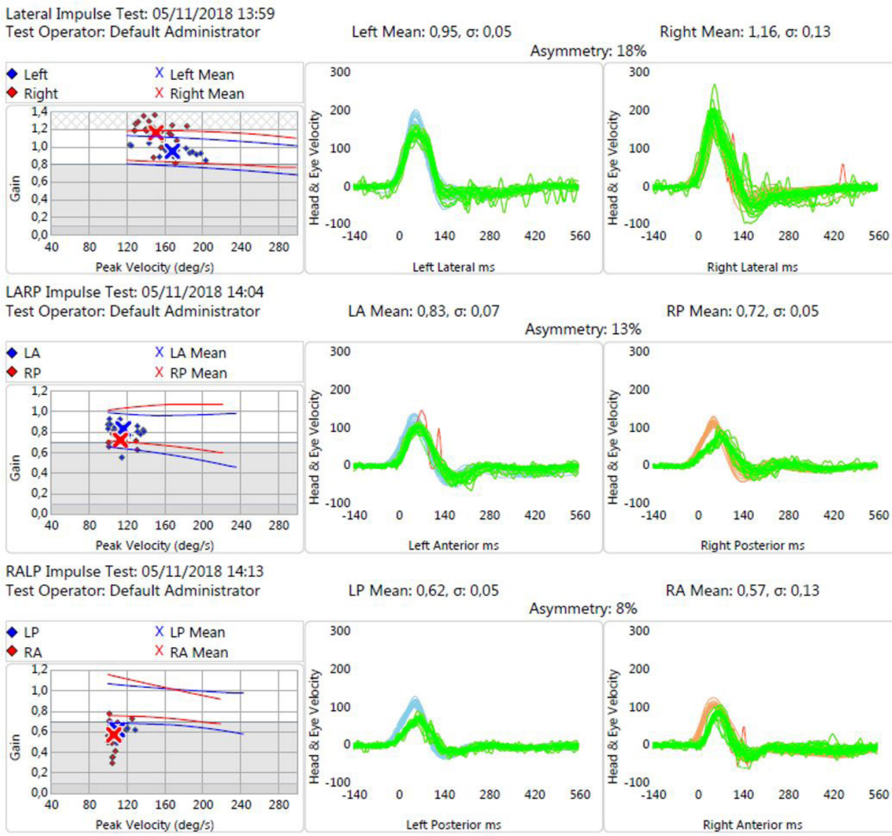

Figure 2. Examination of participants with type 1 diabetes mellitus
Subtitle: LARP = *left anterior and right posterior*; LA = *left anterior*; RP = *right posterior*; RALP = *right anterior and left posterior*; RA = *right anterior*; LP = *left posterior*

Table 2. Exam velocity in both groups, with and without diabetes

Velocity (100-250º/s)		Diabetes		p-value
		Absent	Present	
Left Lateral	Average	178	161	
	Median	**180**	**160**	**<0.001***
	Minimum	120	130	
	Maximum	240	200	
	Standard Deviation	23.7	15.5	
Right Lateral	Average	168	158	
	Median	160	160	0.054
	Minimum	120	130	
	Maximum	240	200	
	Standard Deviation	23.4	13.9	
Left Anterior	Average	122	124	
	Median	120	120	0.416
	Minimum	100	110	
	Maximum	180	140	
	Standard Deviation	10.6	9.7	
Right Anterior	Average	124	118	
	Median	**120**	**120**	**<0.001***
	Minimum	110	110	
	Maximum	160	140	
	Standard Deviation	10.1	9.0	
Right Posterior	Average	127	127	
	Median	120	130	0.715
	Minimum	110	110	
	Maximum	180	150	
	Standard Deviation	12.9	10.5	
Left Posterior	Average	129	120	
	Median	**130**	**120**	**<0.001***
	Minimum	110	110	
	Maximum	160	160	
	Standard Deviation	12.7	12.6	

Mann-Whitney test *p<0.05

thresholds changes in these individuals, when considering only high frequencies thresholds. Out of 35 diabetic individuals, only three (8%) had mild and moderate sensorineural hearing loss. Six (16%) participants showed changes in hearing thresholds at frequencies of 6 and 8 KHz, that is, only at high frequencies. All participants with DM1 exhibited type A tympanometry[25].

The group composed of individuals with DM1 also showed values within the normal range of gain for almost all SC, except for the right posterior canal, which average gain was less than the reference value (0.73). However, it showed statistically smaller gains, when compared to the group without diabetes, also in the right and left posterior canals, as well as in the left anterior canal. Participants with DM1 had no complaints of dizziness according to the answers to the questionnaires applied. Another study also found otoneurological changes in individuals with asymptomatic DM1, using the caloric test[10].

Studies on the vestibular function of individuals with DM1 with the use of v-HIT are scarce in the literature. Only one study was found that was carried out with a pediatric population and no statistical difference was found[26]. In the other studies, the vestibular assessment was carried out using oculomotor tests and caloric test in this population. A study that evaluated 29 individuals showed alterations in the caloric test in 36.8% (n=7) of the sample, 21.1% (n=4) with altered labyrinth predominance, two to the right and two to the left, and 15.8% (n=3) with altered directional preponderance of nystagmus, one to the right and two to the left[10]. In the group of patients with DM1, 14.3% (n=1) had no complaints, 14.3% (n=1) complained of dizziness due to other causes and 71.4% (n=5) complained about dizziness in specific episodes of hypoglycemia. The results showed that five of these individuals with DM1 (26.3%) exhibited alterations in the vectoelectronystagmography, among who three individuals (15.8%) with deficient peripheral vestibular syndrome and the other two (10.5%) exhibited irritative peripheral vestibular syndrome[10].

A study carried out with a sample of 46 patients with DM1 found alterations in the caloric test of electronystagmography in 26.0% (n = 12) of the patients, 4.3% (n = 2) with a predominance of right labyrinth and 21.6% (n = 10) with altered directional preponderance, six to the right and four to the left[27]. Sherer & Lobo (2002) found, in a sample of 12 individuals with DM1, that 50.0% (n = 6) exhibited directional preponderance of altered nystagmus and the other 16.7% (n = 2), altered labyrinthine predominance, without specification as to which side[28].

These findings can be explained by the fact that glucose metabolism has a great influence on the inner ear, both in hypoglycemia and in hyperglycemia, which can cause auditory, vestibular or mixed symptoms. It is known that labyrinthine structures, especially the stria vascularis, have intense metabolic activity and depend on the constant supply of oxygen, glucose and adenosine triphosphate (ATP)[29]. Glucose is a fundamental substance for the production of ATP inside the cells and for providing energy for the functioning of the endolymph sodium and potassium pump[28,29]. Thus, glucose metabolism disorders alter the ions in the endolymph and perilymph, causing a change in the labyrinthine electrical potentials, which may cause dizziness[10,13,29,30]. Glucose metabolism provides the energy required for maintaining the difference in endolymphatic and perilymphatic potential, and the difference in neuronal transmembrane potential, which will allow peripheral information to reach the central nervous system and be properly processed[10,13,29,30].

Although in the group with DM1, lower velocities have been applied for stimulation of the left lateral, right anterior and left posterior SC, in comparison with the control group, for all SC, in both groups, adequate velocity was applied, as recommended in the literature and in the equipment manual for reliable examination - above 120°/s for the lateral canals and 100°/s for the vertical canals[21-24]. In addition, for these SC, there was no statistical correlation between the velocity and the value of the VOR gain.

The right posterior canal was the only one that showed a gain below the normal range in the group with diabetes. However, no corrective saccades were observed, although expected when a reduction in the vestibulo-ocular reflex gain occurs[20-23]. The exams that showed vestibular hypofunction were repeated to confirm the findings. The absence of corrective saccades, in the presence of an altered gain, considering the technique of proper execution of the exam, may correspond to central neurological involvement[20]. Further studies are required to assess the potential correlation of this finding in patients with DM1.

In view of the results found in this study, it is suggested that greater attention be paid to the vestibular system of individuals with DM1, through otoneurological investigation, since individuals with DM1, without dizziness complaints, may exhibit hypofunction in the SC. The dizziness symptom may appear later, with harmful effects on the quality of life. Thus, we emphasize the importance of detecting vestibular hypofunction early in this population and monitor it, in order to avoid worsening the pathology.

This study was limited by the sample size of individuals with DM1, indicating the importance of carrying out studies with a larger number of individuals, so that the data can be confirmed or compared.

The v-HIT is a fast, useful, non-invasive exam, which does not require preparation or fasting before the exam and allows a detailed assessment of the SC, proving to be a desirable exam for assessing the vestibular function of individuals with DM1. Its usefulness in clinical practice has been increasingly consolidated by studies, due to its practicality and objectivity in diagnosing vestibular disorders[22-24,26].

In some individuals, especially the elderly with eyelid ptosis, there was difficulty in capturing the pupil clearly, through the equipment camera. Thus, to raise the upper eyelid, an adhesive tape was placed across the participant's eyebrow. Proper pupil capture and precise cephalic movements are essential to properly stimulate SC[17-19,22,26].

It is important to note that, although v-HIT is a practical and objective test to evaluate each semicircular canal at physiological frequencies, the tests are complementary tools for vestibular assessment and no single test is able to fully assess all structures of the vestibular system.

CONCLUSION

The DM1 group showed less gain in the vestibulo-ocular reflex in the posterior canals and in the left anterior canal, when compared to individuals in the group without diabetes. Corrective saccades were not observed in any of the groups.

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