Postural balance and associated factors with the fall risk assessed in older adults with type 2 diabetes mellitus

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Abstract

Objective: Identify clinical-functional factors associated to the risk of falls, assessed by Mini-BESTest in older adults with type 2 diabetes mellitus (T2DM). *Method:* This cross-sectional study. A total of 145 older adults aged ≥60 years were evaluated through sociodemographic variables (sex, age group, married, education level, general health status hearing and vision), Mini-BESTest, Mini-Mental State Examination (MMSE), Geriatric Depression Scale (GDS-15) and dual-task Timed Up and Go Test (TUG). Multiple logistic regression model was used. *Results:* The sensory orientation domain presented the highest average score, followed by the gait stability, anticipatory postural adjustments and postural responses domains. Factors associated to the risk of falls in older adults are: poor/very poor visual perception OR 3.40 (1.50-7.72); have respiratory diseases OR 8.00 (1.32-48.46); feeling dizzy OR 2.53 (1.10-5.80); and TUGT (dual task) time equal to or greater than 13.5 seconds OR 3.31 (1.03-10.64). *Conclusion:* Older adults in this study presented impaired postural balance, mainly in the postural responses domain. The knowledge of the factors associated with the risk of falls in older adults with T2DM allows for better guidance in prevention, assessment and intervention, in order to minimize the occurrence of falls and maintain or optimize postural balance. Several factors influenced this outcome, such as overweight, low physical activity and education, several comorbidities, polypharmacy, T2DM diagnosis for more than ten years, negative perception of general health and vision, and depressive symptoms.

Keywords: Older Adults. Accidental Falls. Postural Balance. Diabetes Mellitus. Health Evaluation.

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Funding: MCTI/CNPq. Nº do processo: 14/2014. Projeto do edital Universal.
The authors declare that there is no conflict in the conception of this work.

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Received: June 26, 2023
Approved: November 21, 2023

http://dx.doi.org/10.1590/1981-22562024027.230161.en

INTRODUCTION

Disability related to type 2 diabetes mellitus (T2DM) critically affects older adults and is recognized as an emerging health problem related to increased life expectancies worldwide. Also, T2DM can cause several complications and impair postural control (PC) due to decreased proprioception and strength and increased stiffness in ankle joints[1].

Individuals with T2DM present a higher fall risk than healthy individuals in the same age group. The prevalence of falls among older adults with and without diabetes was 25.0% 18.2%, respectively[2]. Older adults with T2DM may present balance impairments and falls due to impaired sensory systems (e.g., impaired proprioception in lower limbs due to neuropathy). The main cause of falls is the loss of balance due to impaired PC (e.g., impaired visual, somatosensory, auditory, and vestibular systems or mixed, motor and autonomic disorders)[2].

Comorbidities related to complications of individuals with T2DM are common, such as hypertension, cardiovascular disease, vascular disease and the risk foot ulceration and/or lower extremity amputation[3].

The use of a cutoff point to classify older adults at risk of falls can be a useful tool in early identification and targeted interventions to prevent falls and improve balance. Additionally, by providing detailed information on the domains of the Mini-BESTest that were compromised, the study allows for a comprehensive understanding of balance impairment in this population.

These contributions help to contribute to the literature, in addition to providing valuable insights for healthcare professionals who work with older adults with T2DM, helping to identify and effectively treat balance problems and fall risk in this specific population.

This study aimed identify clinical-functional factors associated to the risk of falls, assessed by Mini-BESTest in older adults with type 2 diabetes mellitus (T2DM).

METHOD

We conducted a cross-sectional study (random sample) with older adults aged ≥60 years of both sexes and diagnosed with T2DM. The study included older adults diagnosed with T2DM by a physician, who provided their laboratory tests for evaluation.

We excluded older adults submitted to balance rehabilitation in the last six months; unable to understand or follow simple verbal commands or repeat movements; with severe visual or auditory impairment hampering to perform activities of daily living (even with corrective lenses or hearing aids); with lower limb amputations (regardless of the level); unable to independently walk; or walk using assistive devices.

The outpatient assessment was performed at the university hospital in Rio Grande do Norte, over the course of one year, starting in August 2015 and ending in August 2016, the evaluated patients were referred from the gerontology and endocrinology outpatient clinics of the Onofre Lopes University Hospital.

The BESTest is a clinical tool that assesses balance, fall risk, and domains that could be focused during rehabilitation[5]. This test comprises six systems that may impair balance: biomechanical constraints, stability limits, postural responses, anticipatory postural adjustments, sensory orientation, and stability in gait[5].

The Mini-BESTest comprises 14 tests and 16 items (bilateral assessment), completed between 15-20 minutes. Scores range from 0 to 28 points[7,8]. The suggested cutoff point of the Mini-BESTest to identify older adults with history of falls was 20.5 of 28 points, with 60% sensitivity and 71% specificity to identify changed postural responses[6,7].

Questions are divided into four domains corresponding to the systems that maintain the PC:

1. Transitions and anticipatory postural adjustments;

2. Postural responses to disturbance;

3. Sensory orientation;

4. Stability in gait.

Each item is scored on an ordinal scale of 3 points (0 to 2); 0 is the worst performance and 2 is the best[4]. The dual-task TUG assesses the ability to perform two different tasks simultaneously. Older adults were asked to perform the TUG and simultaneously evoke as many animal names as they could remember. Older adults were seated with feet on the floor and back supported on the chair. After the evaluator commanded, older adults should stand up, walk three meters, turn around their axis and return to the starting position[8]. A chronometer measured the time to cover the distance, and older adults were encouraged to walk at their usual speed[5]. They were classified into two groups based on the test time: high fall risk (≥13.5 seconds)[9,10].

We used a questionnaire to identify age, sex, marital status, education level, and, reported diseases, number of medications, perceived vision and hearing.

History of falls in the last 12 months and fear of falling were evaluated through the following questions: "did you fall in the last 12 months?"; "are you afraid of falling?" All older adults were asked about chronic dizziness (i.e., ≥ two months of dizziness). Dizziness was defined as the sensation of disturbed or impaired spatial orientation with no false or distorted sense of motion, not including vertiginous sensations[11]. Dizziness was assessed through the question "have you felt dizzy in the last two months?"

Older adults were also asked about the time of T2DM diagnosis, values of glycated hemoglobin (%) and fasting glucose (mg/dL) in the last six months and ongoing medication for diabetes (oral medication, insulin or both).

Regarding functional variables, height (m) was measured using a tape attached to the wall, and body mass (kg) was measured using a platform scale. Body mass index (BMI; kg/m^2), also known as the Quételet index[14,15], was based on the Nutrition Surveillance System (SISVAN) of the Brazilian Ministry of Health. Cutoff points were determined and classified as underweight (≤22), eutrophic (23 to 26), and overweight (≥27)[12,13]. Regular physical activity was defined as ≥ three times a week for >30 minutes during the last two weeks[14].

Muscle strength was assessed using a Saehan dynamometer and conducted according to the American Society of Hand Therapists[15]. During the handgrip strength test, the evaluator instructed the older adult to maintain the maximum strength. Three measures were collected, with an interval of one minute between each attempt. Results were obtained from the mean of the three measures (kg), and values were adjusted by sex and BMI[16].

Psycho-cognitive data were assessed using the Mini-Mental State Exam (MMSE) and Geriatric Depression Scale Abbreviated (GDS-15). The MMSE is widely used to assess cases of suspected cognitive deficits[17,18] and its reliability and validity were considered satisfactory[19]. Cutoff points were adopted according to years of education: illiterate (20 points); one to four years (25 points); five to eight years (26 points); nine to eleven years (28 points); and for more than eleven years (29 points)[20].

The GDS-15 is a quick and easy-to-use tool that identifies depressive symptoms in older adults. This version comprises 15 questions with scores indicating no depression (0 to 4 points), mild to moderate depression (5 to 10 points) and severe or intense depression (11 to 15)[21,22].

We used the Kolmogorov-Smirnoff test verified data normality. Quantitative variables were described as descriptive measures. The analyzed independent variables were sociodemographic, clinical, functional and psycho-cognitive. Statistical significance was set at 5% ($p<0.05$) for all analyses.

In this study, the dependent variable was falls risk of the Mini BESTest, which was analyzed using the SPSS software version 17.0 for Windows. For inferential analysis, we verified the associations between the risk of fall determined by the cutoff points of the Mini BESTest according to age groups (25 points - 60 to 69 years; 23 points - 70 to 79 years; 22 points 80 to 89 years)[8]. Falls risk (Mini-BESTest) (dependent variable) and the independent variables (sociodemographic and clinical functional) using a multivariate logistic regression analysis using the stepwise forward method.

The variables that showed statistical significance ($p<0.20$) in the bivariate analysis were inserted into the adjusted model (sex, age group, educational level, number of illnesses, physical activity and falls in the last year), with those with $p<0.05$ being retained. Multicolinearity test using VIF was conducted. The final model met the assumption of absence of multicollinearity and the Hosmer and Lemeshow test ($p=0.150$) indicated that there are no significant differences between the results predicted by the model and the observed reality.

We hypothesized that the factors associated to the greater risk of falls in older adults with T2DM are female sex, lower educational level, greater number of diseases, use of insulin, negative perception of vision, complaints of dizziness and longer illness duration.

The project was approved by the Research Ethics Committee of the Federal University of Rio Grande do Norte (UFRN), under number CAAE: 45183715.0.0000.5537.

DATA AVAILABILITY

The entire dataset supporting the results of this study is available upon request from the corresponding principal investigator, Adriana Guedes Carlos.

RESULTS

Six older adults were excluded due to lower limb amputations, five due to the use of walking aid devices and one due to severe visual impairment. Most older adults were female (64.8%). Also, most older adults were married (66.9%) and educational level was classified as incomplete elementary school / complete elementary school (34.5%) and elementary school / illiterate (65.5%). The age group was 60-69 years (62.0%), 70-79 years (29.0%) and 80-89 years (9.0%).

In this study, older adults with five or more diseases (39.3%), diseases of the cardiovascular system (78.6%), five or more medications (62.8%), vision poor or very poor (44.8%), hearing poor or very poor (27.6%), six or more years of T2DM diagnosis (71.0), T2DM medication oral (64.8%), handgrip strength low strength (the lowest quintile) (43.4%), none falls in the last year (62.1%), falls risk (Mini-BESTest) (52.4%), regular physical activity (26.2%), body mass index malnourished or normal weight (63.4%), glycated hemoglobin (n=108) up to 8% (normal) (39.3%), fasting blood glucose (n=133) up to 130mg/dl (normal) (50.3%), pain in lower limbs (57.1%), dizziness complaint (44.1%), global cognition positive screening (42.1%), depressive symptoms (GDS-15) 6 or more (47.2%), falls risk (dual-task TUGT) (n=136) and 13.5 seconds or more (high) (77.2%). The sample characterization is shown in Table 1.

The mean total score of the Mini-BESTest was 80,8% ± 4.6% and 95% confidence interval (CI) 78.4-83.3. The average and their respective 95% confidence interval (CI) of the Mini-BESTest domains are presented in Table 2.

Table 1. Characteristics of older adults with Type 2 Diabetes Mellitus followed up at a university hospital in northeastern Brazil in 2016 (N = 145).

Categories	Occurrence	Percent (%)
Number of diseases		
1 – 4	88	60.7
5 or more	57	39.3
Category of diseases		
Infectious and parasitic	0	0.0
Neoplastic (tumors)	10	6.9
Blood, organs, hemopoietic and/or immune disorders	42	29.0

to be continued

Continuation of Table 1

Categories	Occurrence	Percent (%)
Mental and/or behavioral disorders	7	4.8
Eye and annex	29	18.6
Nervous system	9	6.2
Cardiovascular system	114	78.6
Respiratory system	13	9.0
Digestive system	18	12.4
Skin and/or subcutaneous tissue	3	2.1
Musculoskeletal system and/or tissue	57	39.3
Genitourinary	27	18.6
Number of medications		
0 – 4	2	2.4
5 or more	91	62.8
Vision		
Poor / Very Poor	65	44.8
Hearing		
Poor / Very Poor	40	27.6
Time of T2DM diagnosis		
0 – 5	42	29.0
6 or more	103	71.0
T2DM Medication		
Does not use	6	4.1
Oral	94	64.8
Oral insulin +	32	22.1
Insulin	13	9.0
Handgrip strength		
Low strength (the lowest quintile)	63	43.4
Falls in the last year		
None	90	62.1
One fall	27	18.6
Two or more falls	28	19.3
Falls risk (Mini-BESTest)		
No	69	47.6
Yes	76	52.4
Regular physical activity		
Yes	38	26.2
Body Mass Index		
Malnourished or normal weight	92	63.4
Overweight	53	36.6
Glycated hemoglobin (n=108)		
Up to 8% (normal)	57	39.3
Above 8,1% (altered)	51	35.2

to be continued

Continuation of Table 1

Categories	Occurrence	Percent (%)
Fasting blood glucose (n=133)		
Up to 130mg/dl (normal)	73	50.3
131mg/dl or more (altered)	60	41.4
Pain in lower limbs		
Yes	75	57.1
Dizziness complaint		
Yes	64	44.1
Global cognition		
Positive screening	61	42.1
Depressive symptoms (GDS-15)		
6 or more	68	47.2
Falls risk (dual-task TUGT) (n=136)		
13.5 seconds or more (high)	112	77.2
High (low)	24	16.6

T2DM: Type 2 Diabetes Mellitus; GDS: Geriatric Depression Scale; TUGT: Timed Up and Go Test; Mini-BESTest: Mini-Balance Evaluation Systems Test.

Table 2. Percentage of impairment in Mini-BESTest domains among older adults with Type 2 Diabetes Mellitus at a university hospital in northeastern Brazil in 2016 (N=145).

Mini-BESTest Domains	Mean (±SD) in %	95% CI
Anticipatory postural adjustment (%) tasks		
Total	78.2 (17.1)	75.3 to 81.1
Seated to standing	97.1 (14.4)	94.7 to 99.5
Stand on tiptoe	87.1 (25.7)	82.9 to 91.4
Standing on one leg	53.2 (27.6)	48.6 to 57.8
Postural responses (%) tasks		
Total	64.1 (31.9)	58.7 to 69.4
Forward	71.5 (37.9)	65.2 to 77.9
Backward	65.0 (36.8)	58.9 to 71.1
Side	55.0 (39.0)	48.5 to 61.5
Sensory orientation (%) taks		
Total	93.6 (13.5)	91.3 to 95.8
Solid surface	98.2 (9.3)	96.6 to 99.7
Foam Surface	86.7 (28.5)	82.0 to 91.5
Tilt	95.7 (14.0)	93.4 to 98.1
Stability in gait (%) taks		
Total	84.7 (17.70	81.7 to 87.6
Speed	91.8 (19.5)	88.5 to 95.0
Head turn	80.3 (26.6)	75.9 to 84.8
Axis turn	91.8 (20.4)	88.4 to 95.2
Overcome obstacle	80.3 (29.8)	75.4 to 85.3
Timed Up and Go Test	77.5 (29.6)	72.5 to 82.4

*Data presented as average and their respective 95% confidence interval (CI).

Table 3 present the interferential analysis between the variable "falls risk" of the Mini-BESTest and sociodemographic, clinical and functional variables. In the sociodemographic variables there was a significant association between the "falls risk" of Mini BESTest and sex, indicating that males, compared to females, had a worse result on the Mini-BESTest the educational level, married age group no are associated with risk of falls.

In the functional-clinical variables there was a significant association between the "falls risk" of Mini BESTest and hearing and vision, indicating that both a negative perception of hearing and vision as "poor" or "very poor" are associated with a greater balance impairment. In the psycho-cognitive variables there was a significant association between the "falls risk" of Mini BESTest and GDS-15, indicating that a de "six or more" depressive symptoms are associated with a greater balance impairment.

In the functional-clinical variables there was a significant association between the "falls risk" of Mini BESTest and disease of system respiratory, regular physical activity, dizziness complaint and falls risk (dual-task TUGT), as shown in Table 3.

The was not associated with other clinical-functional and psycho-cognitive variables related others diseases classifications, number of medications, T2DM medication, time of T2DM diagnosis, handgrip strength, glycated hemoglobin, fasting glucose, pain in lower limbs BMI and MMSE.

The "odds ratio" values estimated by the multivariate model are shown in Table 4. Older adults with poor/very poor visual perception have three times the chance of falling when compared to those with excellent/very good/good vision; the fact that older adults have respiratory diseases increases the likelihood of falls by eight times; having a feeling of dizziness increases the likelihood of falls twice; and when the TUGT (dual task) time is equal to or greater than 13.5 seconds, the likelihood of falls increases three times.

Table 3. Inferential analysis between the variable "falls risk" of the Mini-BESTest and sociodemographic, clinical-functional and psycho-cognitive variables of older adults with Type 2 Diabetes Mellitus at a university hospital in northeastern Brazil in 2016 (N=145).

Variables and Categories	No	Yes	p-value
Sex			
Male	34 (23.4%)	17 (11.7%)	0.001 *
Female	35 (24.1%)	59 (40.7%)	
Vision			
Excellent / very good / good	50 (34.5%)	30 (20.7%)	<0.001 *
Poor / Very Poor	19 (13.1%)	46 (31.7%)	
Hearing			
Excellent / very good / good	57 (39.3%)	48 (33.1%)	0.010 *
Poor / Very Poor	12 (8.3%)	28 (19.3%)	
Regular physical activity			
Yes	25 (17.2%)	13 (9.0%)	0.013*
No	44 (30.3%)	63 (43.4%)	
Number of diseases			
1 – 4	50 (34.5%)	38 (26.2%)	0.007 *
5 or more	19 (13.1%)	38 (26.2%)	
Respiratory system			
Yes	2 (1.4%)	11 (7.6%)	0.019 *
No	67 (46.2%)	65 (44.8%)	

to be continued

Continuation of Table 3

Variables and Categories	No	Yes	p-value
Falls in the last year			
None	50 (34.5%)	40 (27.6%)	0.046 *
One fall	10 (6.9%)	17 11.7%)	
Two or more falls	9 (6.2%)	19 (13.1%)	
Dizziness complaint			
Yes	20 (13.8%)	44 (30.3%)	0.001 *
No	49 (33.8%)	32 (22.1%)	
Depressive symptoms (GDS-15)			
6 or more	23 (16.0%)	45 (31.2%)	0.002 *
Up to 5	46 (31.9%)	30 (20.8%)	
Falls risk (dual-task TUGT)			
13.5 seconds or +	5 (3.7%)	19 (14.0%)	0.006 *
< 13.5 seconds	59 (43.4%)	53 (39.0%)	

* Qui-quadrado Test; T2DM: Type 2 Diabetes Mellitus; GDS: Geriatric Depression Scale; TUGT: Timed Up and Go Test; Mini-BESTest: Mini-Balance Evaluation Systems Test.

Table 4. Binary logistic regression model for assessment of factors associated with risk of falls in older adults with Type 2 Diabetes Mellitus (N=145).

Predictor category	OR (95% CI)	p-value
Vision		
Poor/very poor	3.40 (1.50 - 7.72)	0.003
Respiratory diseases		
Yes	8.00 (1.32 - 48.46)	0.024
Dizziness complaint		
Yes	2.53 (1.10 - 5.80)	0.028
Dual-task TUGT		
13.5 seconds or more	3.31 (1.03 - 10.64)	0.045

Model adjusted by sex, age group, schooling, number of diseases, physical activity practice and falls in the last year. TUGT: Timed Up and Go Test; OR: odds ratio; CI 95%: 95% confidence interval. Hosmer and Lemeshow test (p=0.150).

DISCUSSION

The present study verified the associated between the risk of falls and sociodemographic, clinical, functional and psycho-cognitive in older adults with T2DM.

The results obtained indicated a greater likelihood of falls in older adults females, with a greater age range, with a greater number of diseases, with the presence of respiratory diseases and depressive symptoms, reports of falls in the last year and difficulty in performing exercise that requires dual task, when compared to the group with low likelihood of falls and consequently lower Mini-BESTest values.

The fact that females presented associated with risk of falls compared to males may be related to hormonal variations, body composition and self-care behaviors, as women tend to seek more medical assistance[23].

T2DM is often associated with an increased likelihood of falls, as assessed by Mini-BESTest. Mini-BESTest averages may vary according to average age[24]. In this study, the average age and performance were 60 to 69 years (62.01%), 70 to 79

years (29.0%) and 80 to 89 years (9.0%). In a previous study, the average age and performance was 60 to 69 years (14%), 70 to 79 years (33%) and 80 to 89 years (34%)[8], indicating that older adults with a lower age range had a higher Mini-BESTest resulting in a lower likelihood of falls. Older adults between the seventh and eighth decades of life showed a decrease in performance in the Mini-BESTest[23].

PC to function efficiently, ensuring a low risk of falls, depends on the performance of three systems: visual, somatosensory, auditory and vestibular[1].

The majority of older adults in the present study reported vision and hearing as poor or very poor. Visual deficit is common in the population of individuals with T2DM, increasing the likelihood of falls by up to 4 times. Worsening vision causes a series of problems such as self-administration of medications, in addition to difficulty adhering to treatment, which can lead to blindness or diabetic retinopathy[25]. These problems result in worsening balance, indicating a deficiency in the visual system, the system responsible for PC[1].

It was observed that the increase in age in the older adults increases the occurrence of hearing loss, when added to T2DM, these individuals tend to the increased the likelihood of falls. Studies report that hearing loss is related to cognitive loss[25]. Common problems found in individuals with decompensated diabetes[26].

A study shows that glucose metabolism influences the physiology of the inner ear, causing vestibular and auditory changes. Dizziness is one of the main symptoms reported by individuals who have vestibular dysfunction. There is an identified relationship between those who experience dizziness and the time taken to diagnose diabetes. In long-lasting cases of the disease, there is generally an increase in blood glucose and glycated hemoglobin levels[27]. Therefore, older adults who report dizziness and have T2DM are twice as likely to fall.

Cognitive impairment can hinder TUG performance in a simultaneous cognitive task, altering gait (e.g. reduced speed and long test duration)[28]. Furthermore, the history of falls was another critical piece of data. These falls were related to reduced balance and difficulty walking, which are even more compromised when the older adults are asked to perform the dual-task TUG[24].

A previous study suggested an association between reduced cognitive function and depressive symptoms in older people with diabetes[7]. According to the GDS-15, the reduction in depressive symptoms in the older adults was related to increased performance in the Mini-BESTest. Furthermore, depressive symptoms can make it difficult to understand and perform on tests[24].

Generally, those with T2DM have other associated diseases such as respiratory diseases, systemic arterial hypertension, obesity and dyslipidemia. Respiratory diseases, as well as T2DM, are classified as the main chronic non-communicable diseases[29]. According to our study, older adults with T2DM have an 8 times the chance of falling. Previous studies report a positive association between a higher risk of falls in individuals with respiratory diseases, such as chronic obstructive pulmonary disease. This is explained by the breathing pattern that leads to changes in PC[30].

Previous research suggests that hospitalization rates rise among older females as the age group increases, as well as for individuals with lower levels of education. Regarding clinical factors, it was observed that there is an increase in hospitalizations in the presence of multiple comorbidities. It was also found that one of the factors that precede hospitalization is the frequent occurrence of episodes of falls[31].

Preventing the risk of falls is a public health challenge. The regular practice of physical activity, the correction of visual impairments, the management of respiratory disorders, the treatment of foot conditions, the modification of environmental risk factors at home and the education of the individual are crucial points that must be worked on. Physical exercise performed for at least 30 minutes three times a week is considered a factor in the prevention and treatment of various comorbidities that tend to arise with the aging process.

We hypothesized that the factors associated to the increased the likelihood of falls in older adults with DM2 were: being female; having less education, a greater number of illnesses, taking insulin, having a negative perception of vision, complaining of

dizziness, having impaired mobility and having a longer illness. The variables that were not significant in the hypothesis were: taking insulin and having a longer illness.

Limitations of the research: many older adults were unaware of the disease. They did not know or remember when they were diagnosed with DM2 or what medications they were taking for diabetes, nor what basic care they should take.

CONCLUSION

The older adults in this study had impaired balance, especially in the domain of postural responses. Several factors might influence poor postural responses, such as excess weight, low physical activity and education, various comorbidities, polypharmacy, diagnosis of DM2 more than ten years ago, negative perception of general health and vision and depressive symptoms. Therefore, the results of this study are of clinical and scientific relevance. This research contributes to research in the field of geriatrics and gerontology, leading to the discovery of new future studies based on the research findings. In addition to assisting health professionals in the appropriate management of elderly patients with DM2, assisting in the accurate diagnosis of the general and functional status of the latter and providing guidance on the appropriate treatment plan.

AUTHORSHIP

- Adriana Guedes Carlos - conceptualization; data curation; formal analysis investigation; methodology; project administration; resources; visualization; writing - original draft; writing - review & editing.
- Vanessa da Nóbrega Dias - conceptualization; data curation; formal analysis investigation; methodology; project administration; resources; supervision; visualization; writing - original draft; writing - review & editing.
- Monica Rodrigues Perracini - conceptualization; investigation; methodology resources; supervision; visualization.
- Flávia Doná - methodology; resources; supervision; visualization.
- André Gustavo Pires Sousa - conceptualization; investigation; methodology; supervision; visualization.
- Juliana Maria Gazzola - conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; supervision; visualization.

Edited by: Marquiony Marques dos Santos

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