Biomechanical Profile of People with Diabetic Neuropathy Attended in Primary Care In East Paulista, Brazil

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Research

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Abstract

Diabetic neuropathy is one of the main complications of Diabetes Mellitus, which can lead to loss of protective sensation, motor alteration, in plantar pressure, generating deformities, abnormal gait and mechanical trauma to the feet.

OBJECTIVE

to evaluate the distribution of plantar pressure, sensory, motor changes and balance in people with peripheral diabetic neuropathy.

METHOD

Cross-sectional study conducted with individuals registered in the municipal public health network of a city in the east of São Paulo - Brazil, with Diabetes Mellitus and Peripheral Neuropathy identified by the Michigan Screening Instrument, sensory-motor changes by the International Consensus, static and dynamic assessments of plantar pressure using Baropodometry with BaroScan and balance using the Berg scale.

RESULTS

Of the 200 individuals evaluated, 52.55% had no plantar protective sensitivity, the static evaluation did not identify changes in the peak of plantar pressure, however in the dynamics the average in the right foot was 6.08 (± 2) kgf / cm2 and 6 , 7 (± 1.62) kgf / cm2 on the left foot, the center of static pressure on the right foot was lower (10.55 ± 3.82) than on the left foot (11.97 ± 3.90), pointing hyper plantar pressure. The risk of falling was high, ranging from 8 to 56 points, with an average of 40.96 (± 10.77).

CONCLUSION

The absence of protective plantar sensitivity, increased pressure, biomechanical changes lead to loss of balance and are predictive of complications in the feet due to diabetic neuropathy.

Introduction

In recent years, although advances have been made in the treatment of Diabetes Mellitus (DM), the chronic complications resulting from blindness, end-stage renal disease and limb amputation are still responsible for important rates of morbidity and mortality [1–3].

Among the complications of diabetes, Peripheral Diabetic Neuropathy (NDP) is the most common and comprises a set of clinical changes that affect the peripheral sensory, motor and autonomic nervous systems, in an isolated or diffuse manner, in the proximal or distal segments. It can be acute or chronic, reversible or irreversible, manifesting silently or with severe symptoms, due to the high level of glucose in the blood. It affects about 50% of people with DM over 60 years of age, and may be present before the loss of protective sensitivity is detected, resulting in greater vulnerability to trauma and greater risk of developing ulcerations [4].

The causes of NDP are multifactorial and are related to long-term hyperglycemia and ischemia of sensitive, motor and autonomic nerve fibers, leading to thickening of the vascular walls and obstruction of blood flow. Symptoms include burning pain, stinging, paresthesia, feelings of cold and heat, and hyperesthesia, which tend to exacerbate at night. Signs include reduced sensitivity to pain, vibration and temperature, hypotrophy of small interosseous muscles (claw and hammer toes), anhidrosis and distention of the dorsal veins of the feet. Autonomic dysfunction leads to an increase in arteriovenous shunts, making the foot warm and insensitive, identified as a foot at high risk for injuries [5].

NDP is the complication responsible for 40–70% of non-traumatic lower limb amputations. Approximately 20% of hospitalizations of individuals with diabetes occur due to lower limb injuries and 85% of lower limb amputations in individuals with DM are preceded by ulcerations, with the main associated factors being foot deformities and trauma [6,7].

Sensory-Motor Neuropathy, one of the manifestations of NDP, causes a gradual loss of tactile and painful sensitivity, called “loss of the protective sensation of the feet”, which makes them vulnerable to trauma. Furthermore, one of the consequences of sensory-motor neuropathy is the atrophy of the intrinsic musculature of the foot, causing an imbalance between flexor and extensor muscles, triggering osteoarticular deformities such as "claw" fingers, "hammer" toes, overlapping toes, head prominences metatarsal and hallux valgus (bunion) [6]. Such deformities alter the pressure points in the plantar region, leading to overload and skin reaction with local hyperkeratosis (callus), which with continuous walking progresses to plantar ulceration [7]. The loss of skin integrity in the situations described above constitutes an important gateway for the development of infections, which can progress to amputation [8].

In view of the magnitude of the problem and the multiple causes that favor the onset of injuries and ulcerations in the feet of people with diabetes, a thorough physiotherapeutic evaluation of the lower limbs is necessary for the early recognition of changes that may reduce the onset of injuries.

Among the resources used to evaluate the feet, baropodometry stands out, a technique that allows to identify the distribution of plantar load, both in an almost static resting position and in movement, by calculating the relationship between force and pressure on a support platform composed of sensors capable of capturing, comparing and measuring pressures in different regions of the plantar surface [9].

Healthy individuals, in a static situation, have a peak of greater plantar pressure in the posterior region of the foot, of up to 6kgf cm^2, however people with NDP may have the distribution of the plantar load modified, with damage to the biomechanics of the feet, balance and gait, allowing increased plantar pressure in some areas of the foot to the detriment of others, predisposing them to the occurrence of injuries. Considering the relationship between risks of foot ulceration and increased plantar pressure, the use of baropodometry assumes relevant clinical applicability in preventing these injuries [10], as well as in evaluating the effectiveness of interventions, conservative or surgical procedures for foot disorders.

The recognition of the most frequent changes in the feet of people with DM by primary care professionals is a necessary condition for the reduction of injuries, since it generates information that allows the direction of the assessment during the care of the multiprofessional team and the prevention of complications.

Thus, this study aims to assess the distribution of plantar pressure in sensory, motor changes and the balance of people with peripheral diabetic neuropathy.

Method

Study design

Cross-sectional, descriptive study of people with Peripheral Diabetic Neuropathy. The study was carried out in Primary Health Care Units (UBS), in the city of São João da Boa Vista - SP, in East Paulista, Brazil, between November 2018 and February 2019.

Participants were recruited when they were consulted at the Basic Health Unit (UBS), at which time they were invited to participate in the study, and upon acceptance, signed the free and informed consent form - ICF.

Individuals with type 2 Diabetes Mellitus (DM2), registered in the municipal public network of the city, aged over 30 years, more than five years of diagnosis of DM and previous diagnosis of Peripheral Diabetic Neuropathy, identified from screening by the Instrument, were included. Michigan Screening System (MNSI) [11]. Exclusion criteria were established as individuals with cognitive impairment that prevented them from meeting requests during care, preventing the complete assessment of the feet.

Among the thirteen basic health units - UBSs in the municipality, considering a 95% confidence interval, among 2542 individuals with DM2 registered in the municipal public network, according to the prevalence estimated by other studies of around 50% 4, a sample error of 6.35%, 1271 were identified, representing people who could present NDP, with a non-probabilistic cluster sample, consisting of 200 individuals, being adopted.

Outcome variables were sensory-motor changes: plantar protective sensitivity, Aquileus reflex, vibratory sensitivity, dermatological changes, motor deformities, muscle strength and function identified according to the International Consensus on Diabetic Foot, 2019; in addition to balance changes, and changes in plantar pressure. In order to characterize the participants, demographic and clinical variables and the use of appropriate footwear were also investigated. Adequate shoes were considered those with soft material and without internal seams, height and width proportional to the size of the foot and its possible deformities with semi-flexible sole [12].

For the physical therapy evaluation of the feet and identification of changes, a thorough physical examination was performed, consisting of sensory and motor evaluation. The sensory evaluation was carried out using the plantar protective sensitivity tests (Semmes-Weinstein 10 g monofilament), vibratory sensitivity (128 Hz tuning fork) and the Aquileu Reflex test, following the guidelines of the Brazilian Diabetes Society, given by the IWDM [12].

The motor / functional evaluation of the feet consisted of muscle strength tests and functional tests in activities of daily living and biomechanics. Muscle function tests were based on the protocols established by Kendall et al. [13], which grades the muscle strength of the foot and ankle from 0 to 5, with degree zero-0 occurring in degree zero muscle strength on palpation. palpable muscle contraction, grade two-2 joint movement with elimination of gravity, grade three-3 complete joint movement against gravity, grade four-4 complete joint movement against gravity and some resistance and grade five-5 normal muscle strength against gravity and resistance.

The functional evaluation of the lower limbs was performed using tests described by Palmer and Epler [14], which use the number of repetitions of movements performed by the subject in the period of 30 seconds, in the standing and sitting positions, as the scale for data analysis. divided into 4 levels: non-functional, poorly functional, reasonably functional and functional. For inversion and eversion movements, the following repetitions are considered: 0 = non-functional, 1–2 = poorly functional, 3–4 = reasonably functional and 5–6 = functional, while for the other movements are considered: 0 non-functional, 1–4 poorly functional, 5–9 reasonably functional and 10-up as functional.

The Berg Balance Scale [15], also called Balance Scale, was used to assess the participants' balance, where the risk of falling is assessed by testing tasks related to day-to-day activities, involving static and dynamic balance. Through this scale, scores between 54 to 56 points indicate risk of mild fall, 54 to 46 indicate moderate risk of fall and scores between 46 – 36 risk of severe fall.

The static and dynamic evaluation of plantar pressure was performed using baropodometry, using the BaroScan platform, which is composed of 4096 sensors distributed over an area of 50x50cm, making it possible to perform these types of exams, as it allows to identify the foot typology, evaluate the distribution of static or dynamic plantar pressures, identify the center of pressure (COP) and the maximum, minimum and average pressure points and account for the area and time of contact of the feet with the ground (contact surface) [16].

The center of pressure (COP) shows the distance between the center of pressure of each foot in relation to the center of body pressure during the path walked between the support and balance phase, occurring the point of application of the vector of the vertical force of the reaction to the ground [10].

Patients were instructed to walk in a straight line through the examination room and when they reached the platform, step first with their right foot on the outward route, and on the return, with their left foot. The route was repeated three times by the patients to calculate the average peak pressure exerted by the feet on the platform [17]. It is noteworthy that all patients underwent a period of adaptation to the equipment, thus minimizing changes due to non-habituation to it, being accepted as a normal value up to 6 kgf / cm2 or 534 kPa, according to the platform used and according to Armstrong and Lavery (1998) [18]. For this study, a platform calibrated in kgf /cm2 was used.

Ethics in human research

The study was approved in 2018 by the institutional research ethics committee with human beings at the Federal University of São Paulo - UNIFESP and Platform Brazil (CAE 2,695,704) and conducted in accordance with national standards that govern clinical research.

Statistical analysis

All data collected were transcribed to a specific data collection form for the study and then entered electronically into a secure database. The data obtained were analyzed according to descriptive statistics and presented according to their nature, through measures of frequency and central tendency.

Results

200 individuals with NDP participated in this study, residing in the city of São João da Boa Vista / SP-Brazil, users and registered in Basic Health Units.

The data regarding the sociodemographic characterization of the studied sample are shown in Table 1.

Among the individuals evaluated, the majority were female, with a mean age of 58.9 ± 14.5 years. About half of the participants had incomplete primary education (43.72%) and were retired (2.0%), with a family income compatible up to 02 salaries (66.33%). (Table 1). The clinical data of the participants are shown in Table 2.

Table 2 reveals relevant characteristics of the sample studied, glycemic values above the references, Glycated hemoglobina (HbA1c) with wide variation (5.1-11.0%) and high levels of blood pressure and overweight.

Regarding chronic complications, peripheral arterial disease was present in 49.5% of individuals, gastrointestinal disorders 32%, retinopathy 17.5%, nephropathy in 2.5%, sexual dysfunction 29%, and amputation in 3.5% of patients. Regarding comorbidities, the most frequent were systemic arterial hypertension (81.5%) and dyslipidemia (56%). As for drug treatment, 82 (41%) individuals used only insulin and 145 (72.5%) metformin and 23 (11.5%) sulfonylureas (gliclazide, glimepiride, glavos, glyphage and glibenclamide).

The results of the sensitive, dermatological and motor evaluations of the sample participants are presented below. (Table 3).

The plantar protective sensitivity was absent in 105 (52.55%) individuals, while the Aquileu reflex decreased in 72 (36.18%) people, the vibratory sensitivity present in 96 (48%) of those evaluated, which shows the diversity changes in sensory sensitivity when evaluating Peripheral Diabetic Neuropathy.

Regarding dermatological changes and motor deformities, the skin was dry in most participants (87.5%), while dermatological changes as the presence of calluses was identified in 75.5% of the individuals and the motor deformity represented by bone prominence in 74% of people.

When analyzing sensitivity and motor changes comparatively between left and right foot, it was found that they were more prevalent in the right foot, except for ringworm and infection.

The classification of strength in the ankle and foot muscles is shown in Table 4.

It can be seen from Table 4 that the degrees of strength 2, 3 and 4 were the most present for all muscles, however there is an expressive frequency of individuals who already manifest diabetic motor neuropathy, with weakening of the intrinsic muscles of the foot, more marked on the right foot.

In Figure 1, it is possible to observe the categorization of the functional analysis of the movements of the feet and ankle in the studied sample.

The finger extension movement was the most functional of the movements, with over 90% of representativeness among the study participants. The minimum number of repetitions was zero, as out of the 200 evaluated, 10 were unable to perform the movements due to other pathological processes affected such as ankle fracture, visual impairment and ulceration.

The baropodometric variables evaluated in this study were the plantar pressure and average, maximum and minimum dynamic plantar pressure, as well as the pressure center (COP) and contact surface area. Regarding the static evaluation, it can be observed that no individual had peak plantar pressure, that is, the mean static plantar pressure in the right foot was 2.72 (±) kgf /cm^2, with a maximum of 5.22 and a minimum of 0.96, and on the left foot, the average of 2.52 (±) kgf /cm^2 with a maximum of 5.61 and a minimum of 0.7.

As for the dynamic assessment of plantar pressure, the average plantar pressure on the right foot was 6.08 (± 2) kgf /cm^2, with a maximum of 8.83 and a minimum of 1.64, while on the left foot the average was 6 , 7 (± 1.62) kgf /cm^2 with a maximum of 13.28 and a minimum of 2.21. On the right foot, 35 (17.5%) individuals had peak plantar pressure above 6 kgf /cm^2 and 44 (22%) on the left foot, representing a high risk for possible ulcerations, since the general average of plantar pressure was already found. if above the reference values (6 kgf /cm^2 or 534 kPa) considered normal for this variable, according to Armstrong and Lavery (1998) [18].

The description of the values of plantar pressures, second right and left foot, static and dynamic evaluation are shown in Figure 2.

The mean of the static COP on the right foot was 10.55 (± 3.82) and on the left foot 11.97 (± 3.90). This analysis explains why the change in postural balance in the study was considered of severe intensity for the risk of falling.

Regarding the contact surface, it can be called the contact area for each foot during the walk10, where statically the average on the right foot was 111.15 (± 57.68) and on the left foot 105, 33 (± 32.9), while in the dynamic examination on the right foot it was 605.92 (± 193.4) and on the left foot 507.08 (± 69.27).

In the assessment of the participants' balance, an average of 40.96 ± 10.77 points was obtained on the Berg Balance Scale, with 06 (3%) individuals presenting a low risk of falling, 68 (34%) moderate risk and 115 (57.5%) serious risk of falling. When analyzing the type of shoes used by the participants, 92 (46%) used appropriate shoes, with orthopedic sandals being the most prevalent 53 (26.5%).

Upon palpation of the peripheral pulses, 25% had an absent anterior and posterior tibial pulse, while the popliteal pulse was present in 76.66% and in 38.33% the pedicle pulse was absent. The temperature of the feet was normal in 60% of those evaluated and the capillary filling was considered decreased in more than half of the individuals (63.33%).

Discussion

Among the total number of individuals evaluated in this study, plantar protective sensitivity was absent in more than 50% of them and decreased by 36.68%. There was a high percentage of individuals with muscular and dermatological changes, being more evident in the right foot. More than half of the patients had balance changes with a moderate and increased risk of falling, with slightly less than half wearing appropriate shoes. Furthermore, it was possible to identify an increase in plantar pressure, above the values considered normal in the healthy population, especially in the individuals' left foot.

These findings are worrisome since the dermatological and muscular alterations cause the displacement of support and pressure areas in a contralateral way during the walk. Thus, in their presence, there may be an increase in the contact of the foot with the ground in some areas and a decrease in this contact in opposite areas of the plantar surface. These changes associated with loss of protective sensitivity compromise the biomechanics of the feet, altering gait and balance and increasing the risk for the development of plantar ulcers in individuals with NDP.

In NDP, the impairment of fine fibers of type Aδ and C[19], cause a decrease in plantar protective sensitivity, especially regarding the tactile, thermal, pressure and proprioception perception, and the absence of the latter leads to the loss of deep tendon reflexes [20]. Thus, neuropathy leads to insensitivity, and subsequently to foot deformity, with the possibility of developing abnormal gait [21]. Still, due to the lack of a painful response, NDP favors the repetition of trauma in the tissue, and dermatological and bone changes such as calluses and bone prominence [22].

In addition, when there is damage to the peripheral nervous system, a significant deficit in muscle strength can be evidenced, which can lead to losses in the strategies necessary to maintain the stability and balance of the human body during gait, leading to serious future losses, such as ulcerations [23].

Maintaining the balance of the human body depends on the intrinsic coordination of the vestibular system, vision and tactile and proprioceptive information. These components work in an integrated and complementary way and any change in one or more of these systems results in postural instability and, consequently, increases the risk of falls, skin lesions, fractures and prolonged immobilizations [24]. In the present study, 57.5% had a serious risk of falling due to changes in balance, showing that sensory deficit is one of the main causes of postural instability in people with diabetic neuropathy.

Thus, it is evident that the patients included in this study have favorable conditions for the development of plantar injuries and that they would benefit from the implementation of systematic assessment strategies and early interventions to prevent complications resulting from the conditions imposed by the underlying disease.

The evaluation of plantar pressure using baropodometry in order to identify the increase in plantar pressure in vulnerable areas in the feet of people with NDP, has been widely used, as demonstrated by Arts et al (2012) [25] and Waaijman et al (2012) [26], to enable changes in patients' shoes and insoles to obtain adequate footwear, with reductions in peak plantar pressure and decreased risk of pre-ulcerations and ulcerations in these individuals [16,27].

NDP is a factor that is related to the increase in plantar pressure mainly in the anterior region of the feet (metatarsal head), and these values of peak plantar pressure expressed in kgf /cm^2 or kPa, correspond to the average of the pressure values occurred by region of the sole of the foot (hindfoot, midfoot and forefoot) during dynamic baropodometry, showing the influence that foot deformities have on peak plantar pressure values [10]. Therefore, it appears that in our study there was an increase in plantar pressure in the dynamic examination due to the presence of these deformities.

The pressure center (COP) is a parameter that represents a weighted average of the total pressure exerted on the surface in contact with the ground, where its trajectory and displacement parameters can be adopted as indicators of balance and body posture, thus becoming crucial tools in providing information regarding the postural balance of individuals with NDP [28], in addition to formulating an index capable of evaluating the effectiveness of rehabilitation devices, such as orthoses, dynamic study of the function and process of rolling the foot, calculating the degree of twisting the axis of the foot joint and assessing movement, which can show us the reliability of these parameters for such changes [29].

According to Armstrong, Boulton and Bus (2017) [30] it is likely that there is a relationship between these variables, mean peak plantar pressure, pressure center and contact surface, because with the increase in the time of diagnosis of diabetes, there is an increase in plantar pressure and a greater oscillation of these individuals. Therefore, understanding this process would optimize the physiotherapeutic assessment and treatment procedures, as well as providing early action in the prevention of falls and ulceration.

Footwear considered appropriate must have a thick sole, sufficient width and depth to accommodate a sock and the foot comfortably, the inside of the footwear must be soft and seamless, adjustable with laces or velcro, offering total protection to the toes (round or square toe), sole up to three centimeters, and made with soft raw material [7,18,31]. It should be noted that the use of inappropriate shoes has been described in the literature as a relevant factor for the development of the risk of ulceration and peak plantar pressure [17,32–35].

According to Luna et al (2020) [36], the use of inadequate footwear increases the repetitive local mechanical efforts on the foot in patients with DM and NDP, and the accurate measurement of the foot and shoe length is necessary to ensure a correct fit, avoiding the risk of foot ulcer.

According to Collings et al (2019) [37] and Jarls et al (2020) [29], therapeutic / suitable footwear is often used to reduce high tissue pressures associated with the risk of foot ulceration, therefore, guidelines for the care of the feet of people with diabetes recommend the use of therapeutic shoes or personalized insoles in the preventive management of people at risk of foot ulceration, as defined by the National Institute for Health and Care Excellence [38].

Discharge devices such as suitable footwear reduce peak plantar pressure by 14–76% compared to plantar pressure in the bare feet of individuals with NDP [39], which means that adherence to the use of this device is an important contributor to reducing the foot load [40]. Thus, plantar pressure, weight-bearing activity and adherence play a role in the foot load [41].

The findings on plantar pressure and device adherence confirm the importance of providing people with diabetic foot disease with pressure-reducing interventions and ensuring adherence to their use [42]. In addition, the findings emphasize that, to determine foot load, it is important to look beyond a single foot load factor, as single foot load factors are likely to be insufficient to understand treatment progress [43].

In this study, evaluations were performed only in patients with already diagnosed diabetic peripheral neuropathy. Diabetic patients without neuropathy were not evaluated. Thus, it was not possible to carry out measures of association between neuropathy and the presence of changes, with only measures of frequency of changes being presented. Although this is a limitation, the simple description of the occurrence and types of changes in the feet of patients with neuropathy already constitutes an alert factor for physiotherapists and other health professionals who care for individuals with this patholo

Conclusion

Among the total number of individuals evaluated in this study, plantar protective sensitivity was absent or decreased in most of them. Furthermore, a high percentage of individuals with muscular and dermatological alterations were identified, being more evident in the right foot. More than half of the patients had balance changes with a moderate and increased risk of falling, with slightly less than half wearing appropriate shoes. Furthermore, it was possible to identify an increase in plantar pressure, above the values considered normal in the healthy population, especially in the individuals' left foot. These results showed the magnitude of changes that can compromise the biomechanics of diabetic individuals and predispose them to injuries. Thus, in view of the increase in the number of cases of diabetes and consequently of Peripheral Diabetic Neuropathy, it is evident the importance of knowing the profile of this population, as well as their current health situation so that it can be traced to outline strategies for actions directed to the specific needs of this population and the prevention of injuries.

Abbreviations

COP
Pressure center
DM
Diabetes Mellitus
DM2
Type 2 Diabetes Mellitus
HbA1c
Glycated hemoglobina
ICF
Informed Consent Form
MMSI
Michigan Screening System
NDP
Peripheral Diabetic Neuropathy
UBS
Basic Health Unit
UNIFESP
Federal University of São Paulo

Declarations

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AUTHORS CONTRIBUTIONS

JVJ, DSO, MAG, and DMK were involved in the design of the study. JVJ and DMK were involved in data collection, data analysis and interpretation of results. JVJ, MAG, and DMK wrote the manuscript. All authors read and approved the final version.

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AVAILABILITY OF DATA AND MATERIALS

Requests for further detail on the data collected in this study, or data sharing arrangements, can be submitted to Juliana Jorgetto (julianavallim26@gmail.com).

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This project was approved by the Federal University of São Paulo and Plataforma Brasil (protocol number CAE 2,695,704). Informed consent was provided by all participants.

CONSENT FOR PUBLICATION

Not applicable.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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References

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Tables

Table 1 - Sociodemographic characterization of people with diabetes mellitus and neuropathy, Brazil, 2018-2019.

n = 200

Variables	n	%
Sex		
Female	135	67.33
Male	65	32.66
Age range		
<36 years	20	10.05
36-46	28	14.07
47-57	33	16.58
58-68	63	31.66
69-79	38	19.10
80-90	15	7.54
91-95	2	1.01
Color		
White	118	59.30
Parda	25	12.56
Black	55	27.64
Yellow	1	0.50
Education Incomplete Elementary School		
Incomplete Elementary School	87	43.72
Complete Higher Education	26	13.07
Complete high school	42	21.11
Incomplete high school	13	6.53
Complete primary education	17	8.54
Illiterate	9	4.52
Incomplete Higher Education	6	3.01
Labor Activity		
Retired	104	52.76
Sick leave	3	1.51

From home	27	13.57
Occupied	54	27.14
Unemployed	12	6.03
Family income		
From 2 to 5 Minimum Wages	53	26.50
From 2 to 5 Minimum Wages	132	66.33
Above 5 Minimum Wages	15	7.54

Table 2 - Clinical characteristics of people with diabetes mellitus and neuropathy, Brazil, 2018-2019.

n = 200

Variables	**Mean(±DP)**	**Min-Max**
Diagnostic time (yers)	14.06±9.61	05- 45
Weight (kg)	80.73±18.35	45-126
Height (m)	1.63±0.08	1.48-1.80
BMI (kg/cm$^{2)}$	29.15 ± 7.32	27.9-30.3
Abdominal circumference (cm)	108.97 ±15.91	71-206
Glucose (mg/dL)	176.26 ±75.19	33-545
HbA1c (%)	5.76 ±3.11	5.1-11.0
Systolic Blood Pressure (mmHg)	133.07±17.88	93-180
Diastolic Blood Pressure (mmHg)	82.68±11.63	60-120

Table 3 - Distribution of the sensory, dermatological and motor assessment of the feet of the sample participants.

Variables	RightFoot	Left Foot	
Sensitive	**n(%)**	**n(%)**	
Plantar protective sensitivity			
Gift	22(11.06)	22(11.06)	
Reduced	73(36.68)	73(36.68)	
Absent	105(52.55)	105(52.55)	
Aquileus Reflection			
Gift	104(52.00)	83(41.50)	
Reduced	56(28.00)	72(36.00)	
Absent	23(11.50)	24(12.00)	
Vibratory Sensitivity			
Gift	96(48.00)	96(48.00)	
Reduced	60(30.00)	56(28.00)	
Absent	36(18.00)	30(15.00)	
Dermatological			
Dermatological disorders			
Pre-ulceration	07(3.50)	05(2.50)	
Ulceration	04(2.00)	-	
Callosity	151(75.50)	143(71.50)	
Crack	94(47.00)	94(47.00)	
Edema	103(51.5)	89(44.50)	
Ringworm	89(44.50)	91(45.50)	
Hyperpigmentation	62(31.00)	62(31.00	
Dry skin	175(87.50)	175(87.50)	
Infection	02(1.00)	05(2.50)	
Motorcycles			
Motor deformities			
Bone prominence	148(74.00)		141(70.50)
Hallux valgus	42(21.00)		32(16.00)
Claw and / or hammer fingers	42(21.00)		48(24.00)

Table 4 - Frequency and percentage of muscle responses for each ankle and foot muscle assessed.

Variables	n=200	%	Variables	n=200	%
Long finger flexor D			**Long finger flexor E**		
0	09	4.52	0	07	3.52
1	19	9.55	1	12	6.03
2	48	24.12	2	29	14.57
3	56	28.14	3	67	33.67
4	39	19.60	4	52	10.55
5	18	9.05	5	21	5.53
Long flexor of the hallux D			**Long flexor of the hallux E**		
0	09	4.52	0	06	3.02
1	17	8.54	1	12	6.03
2	30	15.08	2	29	14.57
3	62	31.16	3	67	33.67
4	50	25.13	4	53	26.63
5	22	11.06	5	21	10.55
Long finger extender D			**Long finger extender E**		
0	09	4.52	0	06	3.02
1	16	8.04	1	12	6.03
2	28	14.07	2	27	13.57
3	64	32.16	3	68	34.17
4	50	25.13	4	52	26.13
5	21	10.55	5	22	11.06
Long hallux extender D			**Long hallux extender E**		
0	09	4.52	0	06	3.02
1	17	8.54	1	13	6.53
2	28	14.07	2	25	12.56
3	63	31.66	3	69	34.67
4	50	25.13	4	54	27.14
5	22	11.06	5	20	10.05

Lumbrical D			**Lumbrical E**		
0	09	4.52	0	06	3.02
1	17	8.54	1	11	5.53
2	26	13.07	2	27	13,.57
3	64	32.16	3	70	35.18
4	52	26.13	4	53	26.63
5	20	10.05	5	21	10.55
Interosseous D			**Interosseous E**		
0	09	4.55	0	06	3.02
1	14	7.04	1	10	5.03
2	33	16.58	2	27	13.57
3	61	30.65	3	72	36.18
4	51	25.63	4	52	26.18
5	21	10.55	5	21	10.55
Tibialis anterior D			**Tibialis anterior E**		
0	09	4,.52	0	06	3.02
1	13	6.53	1	09	4.52
2	32	16.08	2	26	13.07
3	56	28.14	3	66	33.17
4	59	29.65	4	60	30.15
5	20	10.05	5	20	10.05
Triceps surae **D**			**T**riceps surae **E**		
0	09	4.54	0	06	3.02
1	13	6.53	1	09	4.52
2	32	16.08	2	27	13.57
3	57	28.64	3	67	33.67
4	58	29.15	4	59	29.65
5	20	10.05	5	20	10.05

*D right; E left