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ORIGINAL RESEARCH

Comparison between muscle strength and flexibility of the lower limbs of individuals with and without type 2 diabetes mellitus

Comparação entre pico de torque e flexibilidade dos membros inferiores de indivíduos com e sem diabetes mellitus tipo 2

Comparación entre pico de torque y flexibilidad de los miembros inferiores de individuos con y sin diabetes mellitus tipo 2

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ABSTRACT | To compare the muscle strength and flexibility of the lower limbs of individuals with and without T2DM. The method was a study of the types exposed and unexposed to T2DM. Individuals diagnosed with T2DM, individuals referred to electromyography, and those unexposed to T2DM were included. The exclusion criteria were: individuals over 70 years old; those who for some reason failed to complete one or both tests. The study population consisted of 64 individuals; 34 (53.1%) exposed to DM and 30 unexposed, 50 (78.1%) were female, the mean age was 60.7±7.1 and the dominant lower limb was right in 57 (89.1%) individuals. Comparing individuals with and without a diagnosis of DM, one observed a reduction in the flexion torque on the left at a 120 ° angular velocity in diabetics individuals compared with nondiabetic patients, 25.94±2.26 vs 33.79±2, 4nm, p=0.027, respectively. The reduction in dorsiflexion torque on the right, at a 60 ° angular velocity was observed in diabetics compared with nondiabetic patients, 10.95±0.89 vs. 13.95±0.96nm, p=0.033, respectively. When comparing diabetic individuals with and without a diagnosis of PDN, one observed a greater flexion deficit among neuropathic individuals when compared with non-neuropathic individuals, 46.57±9.47 vs 11.63±13.85nm, p=0.049, respectively. No statistically significant differences were found when comparing groups exposed and unexposed to T2DM, and neuropathic and non-neuropathic diabetics.
Keywords | Muscle Strength; Type 2 Diabetes Mellitus; Muscle Strength Dynamometer; Torque; Lower Extremity.

RESUMO | O objetivo deste trabalho foi comparar o pico de torque e flexibilidade dos membros inferiores de indivíduos com e sem diabetes mellitus tipo 2 (DM2). O método foi o estudo com grupos expostos e não expostos ao DM2. Foram incluídos indivíduos com diagnóstico médico de DM2, encaminhados para eletroneuromiografia, e não expostos ao DM2. Foram excluídos da pesquisa indivíduos com idade superior a 70 anos ou que, por algum motivo, não conseguiram realizar um ou dois dos testes. A amostra foi não probabilística, composta por 64 indivíduos: 34 (53,1%) expostos ao DM2 e 30 não expostos; 50 (78,1%) eram do sexo feminino, a idade média era de 60,7±7,1 anos, e o membro inferior dominante era o direito em 57 (89,1%) dos indivíduos. Comparando indivíduos com e sem diagnóstico de DM2, observou-se redução do torque de flexão à esquerda, em velocidade angular de 120° (25,94±2,26 vs. 33,79±2,4nm, p=0,027, respectivamente). Relatou-se menor valor do

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Corresponding address: Suzane Stella Bavaresco – Rua Buarque de Macedo, 6875, Rio Branco – Nova Prata (RS), Brazil – Zip Code: 95320-000 – E-mail: suzanesbavaresco@hotmail.com – Finance Source: Nothing to declare – Conflict of interest: Nothing to declare – Presentation: Feb. 19th, 2018 – Accepted for publication: Mar. 26th, 2019 – Approved by the Comitê de Ética em Pesquisa da Universidade de Passo Fundo (UPF). Protocol No. 1.587.663.

torque de dorsiflexão à direita, em velocidade angular de 60°, dos diabéticos em relação aos não diabéticos (10,95±0,89 vs. 13,95±0,96nm, p=0,033, respectivamente). Ao comparar indivíduos com DM2, com e sem diagnóstico de neuropatia diabética periférica (NDP), notou-se maior *déficit* de flexão entre os indivíduos neuropatas em comparação com não neuropatas (46,57±9,47 vs. 11,63±13,85nm, p=0,049, respectivamente). Não foram encontradas diferenças estatisticamente significativas ao comparar os grupos de expostos e não expostos ao DM2 e diabéticos neuropatas e não neuropatas.

Descritores | Força Muscular; Diabetes Mellitus Tipo 2; Dinamômetro de Força Muscular; Torque; Membros Inferiores.

RESUMEN | El objetivo de este trabajo fue comparar el pico de torque y la flexibilidad de los miembros inferiores de individuos con y sin diabetes mellitus tipo 2 (DM2). El método fue el estudio con grupos expuestos y no expuestos al DM2. Se incluyeron individuos con diagnóstico médico de DM2, encaminados para electroneuromiografía, y no expuestos al DM2. Se excluyeron de la investigación a individuos mayores de 70 años o que, por algún motivo, no pudieron realizar una o dos de las pruebas. La muestra fue no probabilística, compuesta por 64 individuos: 34 (53,1%) expuestos al DM2 y 30 no expuestos; 50 (78,1%) eran de sexo femenino, la edad media era de 60,7±7,1 años, y el miembro inferior dominante era el derecho en 57 (89,1%) de los individuos. En comparación con individuos con y sin diagnóstico de DM2, se observó reducción del torque de flexión a la izquierda, en velocidad angular de 120° (25,94±2,26 frente a 33,79±2,4nm, p=0,027, respectivamente). Se ha reportado un menor valor del torque de dorsiflexión a la derecha, en velocidad angular de 60°, de los diabéticos con relación a los no diabéticos (10,95±0,89 frente a 13,95±0,96nm, p=0,033, respectivamente). Al comparar individuos con DM2, con y sin diagnóstico de neuropatía diabética periférica (NDP), se notó mayor déficit de flexión entre los individuos neuropáticos en comparación con no neuropáticos (46,57±9,47 vs. 11,63±13,85nm, p=0,049, respectivamente). No se encontraron diferencias estadísticamente significativas al comparar los grupos de expuestos y no expuestos al DM2 y los diabéticos neuropáticos y no neuropáticos.

Palabras clave | Fuerza Muscular; Diabetes Mellitus Tipo 2; Dinamómetro de Fuerza Muscular; Torque; Miembros Inferiores.

INTRODUCTION

Non-communicable chronic diseases (NCD) are considered a public health problem and the top cause of death in the world, many of them premature[1-3]. Out of the 38 million people who die from NCDs worldwide, 28 million are from economically disadvantaged countries[1,2,4]. In Brazil, these diseases accounted for about 74% of deaths in 2012, in addition to their high morbidity rates[3]. Among the NCDs that cause most morbidities, diabetes mellitus (DM) stands out.

DM is not a single disease, but a group of metabolic disorders that have hyperglycemia in common. This biomarker results from defects in insulin secretion and/or action[5]. According to the classification suggested by the American Diabetes Association[6,7] and the World Health Organization[2], there are four types of DM: type 1 (T1DM), type 2 (T2DM), gestational, and other specific types of DM. T2DM is the most prevalent, being present in 90 to 95% of the cases[5].

T2DM is characterized by a defect in both the action and secretion of insulin when hyperglycemia is manifested. In most cases, both defects are present, but one of them may be prevalent. Generally, T2DM is manifested after the age 40, but it can occur at any age depending on one's lifestyle habits. In this type of DM, patients are not dependent on exogenous insulin to survive; however, in some cases, their use is necessary for a proper glycemic control[5].

As the main chronic complication of T2DM, peripheral diabetic neuropathy (PDN) occurs at the microvascular level and affects about 50% of diabetics over the years, the lower limbs being the most affected area[8]. It is characterized by irreversible change in nerve structure and function, due to demyelination, axonal atrophy and decreased regenerative potential, causing symmetrical pain, sensorimotor loss, and paresthesia[8]. In most cases, it affects the individual's quality of life[8] and increases the risk of foot ulcers, amputations, cardiovascular morbidity, and mortality in general[9].

Longitudinal and cross-sectional studies have suggested T2DM is associated with decreased muscle quality, power and strength, with greater severity in the lower limbs than in the upper limbs[10-12]. This reduction is worsened in the presence of PDN and coronary artery disease (CAD) due to their effects of blood flow deficiency[13]. As a consequence of these factors, muscle atrophy occurs especially in the lower limb distal segment[14,15]. Therefore, muscle quality, power and strength are not the only changes in nerve function caused by T2DM, since premature muscle fatigue can also influence these factors[16,17]. Therefore, such changes

may be the main causes of limitations and of a high level of functional and physical disabilities reported by this population[18-20]. In this way, this study aimed to compare the muscle strength and flexibility of the lower limbs of individuals with and without T2DM.

METHODOLOGY

This is a study of the types exposed and unexposed to T2DM. Sixty-four outpatients with and without diagnosis of Type 2 Diabetes Mellitus were included in the sample. This study was conducted at the Laboratory of Biomechanics of Faculdade de Educação Física e Fisioterapia (FEFF) from Universidade de Passo Fundo (UPF), at the outpatient clinics of neurology, endocrinology and clinical medicine of Hospital São Vicente de Paulo (HSVP) and at the private clinic Serviço de Neurologia e Neurocirurgia (SNN), all located in the city of Passo Fundo (RS).

Study population

The study population consisted of individuals diagnosed with T2DM cared for at the HSVP outpatient clinics and of individuals unexposed to T2DM, also recruited at outpatient clinics within the same institution.

Inclusion criteria

Individuals cared for at the outpatient clinics of neurology, endocrinology and clinical medicine of the HSVP, diagnosed with T2DM through electromyography, and individuals unexposed to T2DM, recruited through an announcement displayed at the participating hospital, were included.

Exclusion criteria

Individuals aged over 70 years or who, for some reason, were unable to perform one test or both of them (tests of peripheral muscle strength of lower limbs and/or flexibility test) were excluded.

Sampling procedure and data collection

A non-probability sampling was used. Individuals who met the inclusion criteria signed the Informed Consent Form (ICF), and the study evaluations were performed at the FEFF/UPF, on a previously scheduled date and time. Then, data collection was started by filling the medical record and the sociodemographic questionnaire. Subsequently, the flexibility test and the tests of lower limb muscle strength (knee flexion and extension, ankle plantar flexion and dorsiflexion) were applied at the Laboratory of Biomechanics of FEFF. These data were collected by the researcher and study collaborators, recorded in paper forms and sequentially numbered according to the order of evaluation.

Statistical analysis

The data collected were typed into an Excel spreadsheet, and statistical analysis was performed using IBM SPSS Statistics (version 22) for Windows. Numerical variables were described as mean±standard deviation or median (percentile25 - percentile75) as they presented normal distribution or not. Numerical variables were expressed as absolute or relative frequency. The associations between exposure to diabetes or peripheral diabetic neuropathy and (1) age, height, body mass, body mass index (BMI) and flexibility were evaluated using the analysis of variance with a classification criterion; (2) gender and dominance, using the Pearson Qui-squared test with correction for continuity. Comparisons of the distribution of peak torque measurements between groups of individuals exposed and unexposed to diabetes, or exposed or unexposed to peripheral diabetic neuropathy were performed using analyses of covariance, in which each peak torque measurement was defined as outcome, exposure to diabetes as an independent variable, and age and body mass index as covariables. Age-adjusted estimated mean torque peaks were described with their respective standard error estimates. Values were considered statistically significant when $p<0,05$.

Protocols used

(1) *Clinical assessment form*.

(2) *Computerized isokinetic dynamometer Biodex Multi Joint System 3 Pro*: first, body mass, height, blood pressure (BP), and heart rate (HR) of all study participants were checked before the isokinetic evaluation. Subsequently, they performed cycling warm-up in an electromagnetic spinning bike (Movement BM 2700) without workload for five minutes and, afterwards, each individual was referred to the isokinetic dynamometer for evaluations.

Then, knee joints (bilateral) were evaluated in flexion and extension movements at angular velocities of 120, 180, and 240 °/s. The individuals were comfortably positioned

in the chair of the equipment supporting the back at 85 ° and adjusting it until the popliteal fossa was supported on the front of the seat. Stabilizing the trunk was needed, thus safety belts were used. Two of them crossed the anterior chest and one was positioned horizontally in the pelvic region. To better secure the thigh, a velcro strap was used above the knee and two centimeters above the medial malleolus, stabilizing the leg making the movement. The axis of rotation of the dynamometer was aligned with the axis of the knee joint. Before starting the test, the participants made three free extension-flexion movements so that all individuals could become acquainted with the equipment. Finally, a series of five repetitions of the knee flexion and extension movements was performed, through a concentric contraction of the agonist muscle group followed by another one of the antagonist group, with a 60-second interval between each angular velocity.

To evaluate the peak torque of the plantar flexors and ankle dorsiflexors, the individual was placed in supine position on the bench, with hips and knees bent at 80° and 30 °, respectively, and the knees supported in the popliteal area. The knee and ankle to be tested and the lumbar region were stabilized using a sturdy cushion, and the contralateral foot rested on a support. The individual's hands were placed on the armrest. Dorsal flexion and plantar flexion were tested at 30 and 60 °/s angular velocities. Each movement was repeated five times at both velocities through a concentric contraction of the agonist muscle group followed by another one of the antagonist group, with rest intervals of 60 seconds between each angular velocity.

The parameters of the isokinetic dynamometry evaluated for the different knee and ankle movements were peak torque (PT), muscle deficit between right and left limbs, and agonist/antagonist relationship, respectively.

(3) *Sit and reach box – WCS Cardiomed*: sit and reach test. In this test, the subject was seated on a mat, with the arms fully in contact with the front of the seat and the lower limbs with knees extended and hips bent. After correctly positioned, the individuals were instructed to push the scale ruler of the bench forward as far as possible, thus bending the trunk. The value obtained for each trial was expressed in centimeters and immediately written down by the evaluator. The participants made three attempts and the one whose value was higher was considered for data analysis.

Ethical considerations

The voluntary character, without prejudice to the assistance in case of refusal, is guaranteed to all the individuals who participated in this study. Possibly, the muscle discomfort from the (biomechanical and flexibility) evaluations was the only additional discomfort determined by the participation. The benefits were not direct, but the participants could have their muscles and flexibility of the lower limbs reliably evaluated. The results and medical records of the evaluations were hand over to the participants, who were provided with explanations and clarified their doubts with the researcher responsible. Therefore, being aware of the results, the participants can seek treatment (since it will not be given by the researcher) to reduce the effects of decreased lower limb strength, according to the orientations provided.

RESULTS

The study population consisted of 64 individuals, 34 (53.1%) exposed to DM and 30 unexposed to DM. Among them, 50 (78.1%) were female, the mean age was 60.7±7.1 years, and the right lower limb was dominant in 57 (89.1%) individuals. As described in Table 1, the individuals exposed to DM were older, 62.8±6.73 vs. 58.2±6.94 years, p=0.009, and their BMI was higher, 29.82±5.20 vs. 27.99±3.89 kg/m^2, p=0.027, than that of those unexposed to T2DM, respectively. No statistically significant difference between the groups was observed regarding dominance, weight, height, and flexibility.

Table 1. Sample description

	Groups		p
	Unexposed to T2DM (n=30)	T2DM (n=34)	
Gender (F)	24 (80.0 %)	26 (76.5%)	0.970
Dominance (D)	28 (93.3%)	29 (85.3%)	0.531
Age (years)	58.2±6.94	62.8±6.73	0.009
Weight (kg)	70.4±10.9	76.6±14.5	0.058
Flexibility	21.06±8.69	23.13±10.65	0.401
Height	1.60±0.07	1.60±0.094	0.845
BMI	27.99±3.89	29.82±5.20	0.027

Values express absolute and relative frequency or mean±standard deviation.

When comparing individuals with and without T2DM diagnosis, lower values of flexion torque on the left, at a 120 ° angular velocity, were observed for those diagnosed with T2DM compared with those unexposed to T2DM, 25,94±2,26 vs, as Table 2 shows. 33.79±2.4nm, p=0.027, respectively.

Table 2. Comparison of the peak torque of extensor and flexor muscles between groups: unexposed to T2DM and exposed to T2DM; T2DM without PDN and T2DM with PDN

	Group		p	Group		p
	Unexposed to T2DM (n=30)	T2DM (n=34)		Without PDN (n=11)	PDN (n=23)	
Angular velocity 120 °						
Right extension	76.06±5.3	73.2±4.9	0.703	73.91±7.69	73.22±5.26	0.942
Left extension	80.15±4.7	70.07±4.4	0.141	77.52±7.00	65.07±4.78	0.158
Extension deficit	18.67±6.3	23.5±6.2	0.612	15.10±6.65	22.82±4.55	0.353
Right flexion	30.5±2.5	27.37±2.4	0.264	26.20±3.66	26.56±2.50	0.936
Left extension	33.79±2.4	25.94±2.26	0.027	28.41±3.45	23.66±2.36	0.271
Flexion deficit	31.04±8.32	39.95±7.77	0.458	11.63±13.85	46.57±9.47	0.049
Angular velocity 180 °						
Right extension	64.23±4.76	60.89±4.44	0.625	62.40±7.62	60.89±5.21	0.874
Left extension	66.83±3.96	60.65±3.7	0.279	67.91±6.12	56.28±4.18	0.133
Extension deficit	18.08±4.8	18.96±4.5	0.899	20.79±5.02	14.96±3.43	0.352
Right flexion	30.36±2.3	24.54±2.16	0.083	23.01±3.43	25.03±2.34	0.635
Left extension	31.05±2.25	25.58±2.10	0.094	28.79±3.41	23.41±2.33	0.208
Flexion deficit	23.50±4.07	25.30±3.80	0.757	29.14±5.89	25.26±4.02	0.596
Angular velocity 240 °						
Right extension	58.61±4.26	55.01±3.98	0.557	59.88±7.12	53.22±4.87	0.453
Left extension	60.65±3.64	52.86±3.40	0.140	58.46±5.53	49.81±3.78	0.214
Extension deficit	16.33±3.93	14.83±3.68	0,790	12.26±4.35	15.87±2.97	0.504
Right flexion	28.82±2.16	25.10±2.02	0.234	27.21±3.59	24.10±2.45	0.487
Left extension	30.02±2.04	24.93±1.91	0.087	28.39±3.21	23.40±2.19	0.215
Flexion deficit	15.35±3.33	21.12±3.11	0.231	22.56±5.37	18.74±3.67	0.567

T2DM: type 2 diabetes mellitus; PDN: peripheral diabetic neuropathy; p: probability value. Values express mean±standard error, adjusted by age and BMI.

As described in Table 3, reduction in dorsiflexion torque on the right was observed for individuals exposed to T2DM and unexposed to T2DM, at a 60 ° angular velocity compared with those unexposed to T2DM, 10,95±0,89 vs. 13.95±0.96nm, p=0.033, respectively. No statistically significant differences were observed between groups regarding the other biomechanical measurements.

Table 3. Comparison of the peak torque of plantar flexor and dorsiflexor muscles between groups: unexposed to T2DM and exposed to T2DM; T2DM without PDN and T2DM with PDN

	Group		p	Group		p
	Unexposed to T2DM (n=30)	T2DM (n=34)		Without PDN (n=11)	PDN (n=23)	
Angular velocity 30 °						
Right plantar flexion	52.61±3.54	46.92±3.31	0.266	51.42±5.80	43.37±3.69	0.268
Left plantar flexion	57.81±3.58	48.20±3.34	0.065	52.39±5.26	44.36±3.59	0.224
Deficit in plantar flexion	20.10±4.29	25.09±4.00	0.418	18.33±6.90	27.94±4.71	0.266
Right dorsiflexion	18.79±1.95	14.39±1.82	0.120	15.23±1.50	14.19±1.02	0.581
Left dorsiflexion	17.02±1.31	14.70±1.22	0.220	15.08±1.88	14.63±1.28	0.848
Dorsiflexion deficit	33.66±9.13	26.62±8.53	0.592	14.12±10.68	32.95±7.30	0.162
Angular velocity 60 °						
Right plantar flexion	45.91±2.93	40.18±2.74	0.177	43.57±4.98	37.63±3.41	0.340
Left plantar flexion	47.74±3.11	39.1±2.91	0.057	45.40±4.68	35.08±3.20	0.083
Deficit in plantar flexion	18.58±3.16	20.67±2.95	0.645	11.22±5.68	24.98±3.88	0.058
Right dorsiflexion	13.95±0.96	10.95±0.89	0.033	12.64±1.16	10.83±0.79	0.217
Left dorsiflexion	14.02±1.17	10.92±1.09	0.070	11.48±1.78	10.94±1.21	0.806
Dorsiflexion deficit	34.71±8.42	20.58±7.86	0.244	25.30±4.40	20.77±3.00	0.409

T2DM: type 2 diabetes mellitus; PDN: peripheral diabetic neuropathy; p: probability value.
Values express mean±standard error, adjusted by age and BMI.

When comparing diabetic individuals with those without PDN diagnosis, neuropathic individuals showed greater flexion deficit compared with non-neuropathic individuals, 46,57±9,47 vs, as described in Table 2, 11.63±13.85nm, p=0.049, respectively. No statistically significant differences were observed between groups regarding the other biomechanical measurements (Tables 2 and 3).

DISCUSSION

In this study, no consistent reduction in biomechanical measurements was observed both for individuals with T2DM compared with individuals without T2DM and for individuals with T2DM and peripheral diabetic neuropathy compared with those without neuropathy. However, although no statistically significant, the mean values both for individuals with T2DM compared with individuals without T2DM and for neuropathic individuals compared with non-neuropathic ones suggest there may be a reduction in torque in these populations, but the study has no statistical power to show it.

The effect of T2DM on muscle strength, especially in the lower limbs, has been confirmed in many studies, in addition to the correlation between the severity of PDN, glycated hemoglobin, and other factors, with the reduced strength[17,20-26]. Some studies affirm that muscular strength is affected by gender, age, and body mass index (BMI)[27]. However, if muscle strength is normalized by the cross-sectional area or muscle mass, the influence of the gender could be diminished[26,28].

A study conducted in 2014 tested the hypothesis that diabetic patients' muscles were weaker than those of healthy individuals. Twelve patients diagnosed for more than 10 years, 18 patients diagnosed for less than 10 years and 20 healthy individuals, of both genders, were evaluated and compared without obtaining significant difference between the groups. This result may have been influenced by the age, gender and small sample size. Maximum peak torque values for flexors and for knee extensors were not affected both in isometric and in isokinetic tests. Also, it was clearly shown that men were significantly stronger than women. In this study, a statistically significant difference was obtained only in the variable "angular velocity of 120 ° in the flexion movement of the left knee" (p=0.027), and, in the other 17 variables, no statistically significant difference was found (p>0.05).

In 2012, the study by Ijzerman et al. aimed to distinguish the effects of T2DM and PDN on muscle strength, quality of life, and mobility. The sample was composed of 98 patients with PDN, 39 patients without PDN, and 19 healthy individuals, of both genders[17]. They performed isometric and isokinetic tests to evaluate the muscular strength of the lower limbs (ankle plantar flexors and dorsiflexors, knee flexors and extensors), SF36 to evaluate the quality of life, and six-minute walk test (6MWT), timed up and go test (TUGT), and a physical activity questionnaire adapted for the elderly to evaluate the mobility of the study participants. As a result, both the group with PDN and that without PDN obtained lower values in the maximal voluntary strength and in all the parameters measured for knee and ankle than those of the control group, but with a statistically significant difference only in the flexion movement of knees, corroborating this study. In addition, no differences were observed between T2DM individuals with and without PDN[17].

Another study by Ijzerman et al.[30] tested the hypothesis that the reduction in muscle strength in T2DM patients without clinically diagnosed PDN resulted from premature nerve damage and that those clinically diagnosed with PDN showed greater muscle weakness than T2DM patients without clinically diagnosed PDN due to increased degradation of the motor nervous system. However, the values obtained in the study agreed with this hypothesis, and the authors suggested the reduction in voluntary muscle strength occurs regardless of motor loss or loss of sensory nerve function in T2DM patients with and without PDN.

In the previous study, the authors suggested three valid conclusions: the first one was that the group of T2DM patients with PDN showed compound muscle action potential, suggesting a smaller amount of muscle mass between the two groups; the second one was that the conduction speed was reduced in the group of T2DM patients with PDN, showing deterioration of nerve function; and the third was that muscle strength was relatively lower in the group of T2DM patients without PDN than in the control group[30].

In 2014, Allen et al.[31] evaluated the effects of PDN on muscle contraction and their relationship with muscle morphology and denervation. Twelve patients (seven men and five women aged between 32 and 78 years) with (non-insulin dependent) T2DM and PDN, confirmed through clinical characteristics and electrophysiological study, and twelve healthy individuals (with the same gender distribution as that of the other group, but aged

between 29 and 77 years) were part of the control group. To evaluate the strength in the dorsiflexion movement, an isometric test was performed only on the dominant leg. It was different from this study, in which both legs were used for evaluation of dorsiflexors and ankle plantar flexors, as well as of flexors and knee extensors, and the test was isokinetic (concentric agonist/concentric antagonist). However, in the study by Allen et al., reduced muscle strength was found for the group of patients with T2DM and PDN, and the reduction in other markers of the tibialis anterior was statistically significant.

Regarding the evaluation method, few studies found used the isokinetic evaluation. Some of them used the isometric evaluation method or, as in the case of two studies cited above, both methods. In addition, the values shown both in the biomechanical evaluations and in the flexibility assessments for a large part of the group of individuals unexposed to T2DM also agreed with the hypotheses of this study, which may indicate an important signal because the values remained below what was expected for some patients, even without T2DM. Therefore, individuals who do not develop T2DM also need a more detailed follow-up and investigations on the muscle health of their lower limbs.

CONCLUSIONS

Based on the results, we can conclude that consistently lower values of the biomechanical measurements and the flexibility of individuals exposed to T2DM evaluated were not found when compared with those of individuals unexposed to T2DM. In addition, no lower values of the aforementioned measurements were found when comparing T2DM individuals with PDN and T2DM individuals without PDN.

The mean values of this sample suggest a decrease in peak torque may exist, even without statistical significance. However, our study has no statistical power to show it.

An important result was realized throughout this study. Some of the individuals of the group unexposed to T2DM showed results above the expected in the biomechanical tests and in the flexibility test. On the other hand, diabetic individuals with and without PDN showed good results in both tests. Therefore, we emphasize the importance of encouraging physical activity and knowledge of T2DM, since a large part of these individuals performed some type of activity and were aware of the effects of this disease in the short and, mainly, long term.

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