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Comparison of Dynamic Balance and Lower Limb Muscle Strength in Type 2 Diabetic Patients with Healthy Individuals

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ABSTRACT

Aims Diabetes is a set of complex disorders in the metabolism of proteins, fats, and carbohydrates, which cause physiological and biochemical changes in nerve cells, causing chronic psychomotor and musculoskeletal disorders such as muscle strength and balance disorders. This study aimed to compare the dynamic balance and muscle strength of the lower limbs in type 2 diabetic patients with healthy individuals.

Instruments & Methods In this cross-sectional descriptive study, 70 patients with type 2 diabetes and 70 healthy people aged 40 to 70 years without skeletal-muscular and cognitive problems were selected by a multistage sampling (convenience, random block) method. In each group, the demographic questionnaire, Berg Balance Scale, and muscle strength were measured with a manual dynamometer. Chi-square, Fisher's exact test, and independent t-test were used to analyze the data.

Findings The mean score of the Berg Balance Scale was higher in the control group than in the type 2 diabetes patients ($p<0.05$). Also, the strength of the selected muscles of the lower limbs, except the plantar flexor, was higher in the control group than in the diabetic patients ($p<0.05$).

Conclusion Dynamic balance and walking independence are more in healthy people than in diabetic patients.

Keywords Dynamic Balance; Diabetes Mellitus; Muscle Strength; Diabetic Neuropathy

CITATION LINKS

[1] Does gender affect health-related quality of life in patients with type 2 ... [2] Comparison of the effect of face-to-face training and educational booklet on ... [3] Diabetic peripheral neuropathy and its metabolic determinants ... [4] Facilitators and inhibitors of self-care behaviors in iranian type 2 ... [5] Effect of proprioceptive exercises on lower extremity proprioception in ... [6] Effect of Yogasana intervention on standing balance performance among people ... [7] The effect of aquatic exercise on postural mobility of healthy ... [8] The effects of physical exercise on balance and prevention of falls in older ... [9] Systematic review and meta-analysis of the effects of foot and ankle physical ... [10] Relationship between postural sway on an unstable platform and ... [11] The effect of water therapy and jogging exercises on the health-related ... [12] Impaired balance is related to the progression of diabetic ... [13] Effect of kinesiotape versus resistive exercise on dorsiflexors functional ... [14] Test-retest reliability of isometric ankle plantar flexion strength measurement ... [15] Measuring balance in the elderly: validation ... [16] Abnormal vibration perception threshold alters the gait features in ... [17] Longitudinal associations between gait, falls, and disability in community-dwelling ... [18] Diabetic peripheral neuropathy compromises balance ... [19] Functional balance and its determinants in older ... [20] The association between fear of falling and functional tests in older ... [21] Investigation of motor electroneuromyography parameters in patients with ... [22] Diabetic foot ulcers: Classification, risk factors ... [23] Loss of lower extremity muscle strength based on diabetic polyneuropathy ... [24] Painful diabetic peripheral neuropathy: health care ... [25] Effects of a combined strengthening, stretching and functional training program versus ... [26] A systematic review on foot muscle atrophy in patients with ... [27] Reduced skeletal muscle quantity and quality in patients with diabetic polyneuropathy assessed ... [28] Infiltration of intramuscular adipose tissue impairs ... [29] The impact of sensory and/or sensorimotor neuropathy on lower limb muscle endurance, explosive ... [30] Lower extremity muscle strength is reduced in people with type 2 diabetes, with and ... [31] Effects of branched-chain amino acids and vitamin D supplementation on physical function, muscle ... [32] Heel rise and non–weight-bearing ankle plantar flexion tasks to assess foot and ankle ... [33] Kinematics and kinetics of single-limb heel rise in ... [34] Reduced lower-limb muscle strength and volume in patients with type 2 diabetes in ...

Introduction

Diabetes is a set of complex disorders in the metabolism of protein, fat, and carbohydrates, which is caused by a lack or relative decrease of insulin or a decrease in the sensitivity of tissues to insulin [1, 2]. One of the common complications of diabetes is Diabetic Polyneuropathy (DPN), the prevalence of which is reported to be 9.6 to 76% among diabetic patients in the world [3].

Lack of proper control of diabetes can cause complications, such as nephropathy, retinopathy, cardiovascular diseases, neuropathy, weakness, disability, and even death [4]. Diabetic neuropathy is characterized by damage to small or large-diameter nerve fibers of the peripheral nervous system. On the other hand, by causing vascular damage due to hyperglycemia and as a result of hypoxia and damage to sensory nerves, it increases and causes changes in the sensory and motor function of the lower limbs [5]. In addition to metabolic complications, diabetes makes physiological and biochemical changes in nerve cells, causing chronic psychomotor disorders, such as impaired dynamic performance and balance [1]. The central nervous system receives signals of altered body orientation. On the other hand, corrective and stabilizing forces are stimulated by the selective activation of muscles to maintain balance and cause imbalance in people with diabetic polyneuropathy, which causes falls, associated injuries, and fractures in the patient [6].

Among the effective factors in the imbalance and muscle weakness of patients with type 2 diabetes are things like lower muscle volume and more accumulation of fat in muscles, especially in diabetic neuropathy, microscopic changes in muscles, such as an increase in the ratio of type 2 fibers and a decrease in oxidative enzymes, an increase in enzymes glycolytic, and reduction of mitochondrial function. In addition, the decrease in gene expression in neurotrophic factors, the decrease in the ratio of phosphocreatine to adenosine triphosphate, the increase in the ratio of fat to water, and disruption in the natural mechanics of the pelvic region due to the weakness of the gluteus medius muscle causes hip adduction and valgus knee, and ultimately balance disorder and muscle weakness [7].

These factors ultimately lead to a decrease in muscle strength [8], a decrease in the speed of contraction in the knee extensor muscles, weakness in the ankle muscles (plantar and dorsiflexors) and knee extensors, a delay in the contraction of the tibialis anterior, gastrocnemius and peroneal muscles during the activity of dorsiflexion and plantar flexion of the ankle, less torque in the knee, ankle and thigh extension, and spending more energy while walking associated with the possibility of falling [9].

Proper balance is the result of the cooperation of various systems, including sensory (especially proprioception), motor, balance, vision, etc. [10-12]. Diabetes directly or indirectly affects all these systems. Carrying out all daily life activities depends on static and dynamic balance control. However, it seems that patients with diabetes, especially type 2 diabetes, experience muscle weakness, especially in the lower muscles, in such a way that due to the change in the mechanical function of the muscles, especially in the lower limbs, the normal pattern of walking changes in these patients. For example, the speed and acceleration of walking decreases, and this issue also leads to discriminatory restrictions in the work environment or even at home for patients with diabetes. Studies have shown a decrease in muscle strength and balance disorder in diabetic patients, especially diabetic neuropathy [7, 9, 11]. But, the comparison of balance and isometric strength between diabetic patients and healthy people has been done less. Therefore, this study aimed to compare the dynamic balance and muscle strength of the lower limbs in type 2 diabetic patients with healthy individuals.

Instruments and Methods

In this cross-sectional comparative descriptive study in 2022, balance performance and lower limb muscle strength were compared between two groups of diabetic patients and healthy individuals. The research population was known type 2 diabetic patients who referred to Imam Reza Clinic in Arak City and their companions.

Participants and sampling

According to the study of Kukidome *et al.* [13], considering the mean and standard deviation of the Berg test (49.31±7.3), the alpha coefficient of 5%, the beta error of 20%, and the approximate difference of 2.4, based on the comparison of means, two groups of 70 people were chosen.

The inclusion criteria for diabetic patients were aged 40 to 70 years with a history of disease and treatment for more than three years and having an active file of diabetes clinic, who had or did not have neuropathy based on the examination and opinion of neurologists. The inclusion criteria in the group of healthy people was the absence of a known disease and under treatment according to self-report. Exclusion criteria in both groups include known and treated musculoskeletal disorders, degenerative diseases under treatment, receiving any medication or musculoskeletal rehabilitation intervention, presence of hearing and visual impairments related to balance such as nystagmus or Meniere's disease, suffering from chronic disease, inner ear infection, sprained ankle, fracture, deformity, or neurological and rheumatology diseases in the lower limbs.

Sampling in two groups was done in a multi-stage manner (easy, randomized block). Eligible patients and healthy individuals were allocated to 5 blocks based on average age, body mass index, sex, and comorbidities, and by simple random sampling method, 2 people were selected in each block by tossing a coin, and the sampling continued until reaching the desired sample size.

Implementation method and data collection

After receiving the code of ethics from the university research ethics committee and obtaining informed consent from the patients, and after explaining the study method, the eligible people were included in the study. At first, demographic and clinical information was recorded based on patient statements and case documents. The laboratory findings included in the file were used if they were recorded in the last one month. Otherwise, all the desired tests (2-hour fasting sugar, glycosylated hemoglobin, and lipid profile) were performed in the laboratory of Imam Reza Clinic in Arak City.

In the present study, the results of dynamic balance and muscle strength of the lower limbs of patients with diabetes and healthy people were compared. Therefore, the strength of selected muscles of the lower limb was measured by a trained and skilled occupational therapist using a Nicolas Hand-Held Dynamometer (HHD) model 01163 (Lafayette company; UK) [14]. In order to create sufficient stability and prevent the movement and displacement of dynamometer during measurement, a strap was used to maintain this device [15]. The test execution method is presented in Table 1.

The Berg Balance Scale (BBS) was used to measure the dynamic balance of the studied subjects. So far, 22 studies have been conducted to investigate the psychometric properties of this scale in different statistical societies, all of which have shown the high reproducibility, validity, and sensitivity of this instrument. Also, until today, the number of studies that have used the Berg Balance Scale to measure balance is more than 900 [16]. This scale includes 14 functional balance tests that evaluate various aspects of a person's daily activities that require maintaining dynamic balance. In all 14 items, each test is scored from 0 to 4. Score 4 means complete ability, and score 0 means inability to perform daily activities, and the whole scale has a total of 56 points. In this test, a lower score indicates a person's lower ability to maintain functional balance, and if the sum of the acquired points of the patient is less than or equal to 20, the patient will need a wheelchair. If the total score of the patient is greater than 20 and less than or equal to 40, the patient will need assistance in walking. Patients whose score is more than 40 can walk independently [16]. All tests were conducted under the supervision and care of the examiner and an accompanying person, and the score of each test was recorded. All tests were performed in the same conditions and environment and with a specific time to reduce the distortion of the instrument, and all the participants were given the same explanations and allowed to perform the test steps after one practice.

Statistical analysis

Data analysis was done using SPSS 21 software. Descriptive statistics for quantitative data were expressed using mean and Standard Deviation (SD), and for qualitative data using frequency and percentage. In data analysis, after determining the normality of data distribution using the Kolmogorov-Smirnov test, chi-square tests and independent t-test or their equivalent non-parametric tests (such as Fisher exact test) were used.

Table 1) The method of performing the muscle strength test in selected muscles of the lower limb

Selected muscles	The position of the subjects	The location of the dynamometer
Dorsiflexors	Sitting on the ground with the hip angle of 90 degrees and the knee in an open position	The lower edge of the HDD sensor is placed above the head of the first metatarsal bone (the surface on the foot).
Plantar flexors	Sitting on the ground with the thigh angle of 90 degrees and the knee in an open position	The lower edge of the HDD sensor is placed above the head of the first metatarsal bone (The surface of the sole of the foot)
Knee extensors	Sitting on a chair with a thigh and knee angle of 90 degrees	The lower edge of the HHD sensor is placed above the surface of the inner ankle (anterior surface of the leg).
Knee flexors	Sitting on a chair with a thigh and knee angle of 90 degrees	The lower edge of the HHD sensor is placed above the surface of the inner ankle (posterior surface of the leg).

Findings

Of the 83 people in the diabetic patient group and 102 people in the healthy group, two groups of 70 people continued the study until the end. There was no significant difference in demographic variables, including age, Body Mass Index (BMI), duration of diabetes, gender, smoking or drug use, and concomitant diseases, between the two study groups (p>0.05; Table 2).

In the comparison of biochemical variables between the two groups, fasting blood sugar (p=0.020) and glycosylated hemoglobin percentage (p=0.001) were higher in diabetic patients than in healthy people. However, the mean levels of cholesterol (p=0.552), triglyceride (p=0.914), urea (p=0.498), and creatinine (p=0.168) were not significantly different between the two groups (Table 3).

None of the samples in the two groups used wheelchairs, and the difference between them was not significant (p=1.00). However, a significant increase in walking assistance (p=0.021) was observed in the diabetic patients compared to the healthy group, and a significant decrease in independent walking was observed in the diabetic group compared to the healthy group (p=0.001; Table 4).

Table 2) Comparison of demographic information of two groups (n=70 in each group; Numbers in parentheses are percentages)

Demographic variables	Diabetic patients	Healthy people	p-value
Age (years)	55.90±6.20	56.70±6.20	0.44
BMI (kg/m²)	28.20±1.71	28.00±1.51	0.77
Duration of diabetes (years)	7.80±2.60	-	-
Gender			
Male	28 (40.0)	31 (44.3)	0.30
Female	42 (60.0)	39 (55.7)	
Smoking or drugs			
No	63 (90.0)	62 (88.6)	
Yes	7 (10.0)	8 (11.4)	
Co-morbidity			
No	50 (71.4)	53 (75.7)	0.84
Yes	20 (28.6)	17 (24.3)	

Table 3) Comparison of biochemical variables in two groups (n=70 in each group)

Variable	Diabetic patients	Healthy people	p-value
Fasting blood sugar (mg/dl)	142.20±29.38	102.28±21.66	0.020
Glycosylated hemoglobin (%)	7.88±1.03	5.44±0.94	0.001
Cholesterol (mg/dl)	212.59±74.44	205.06±11.68	0.552
Tri glyceride (mg/dl)	245.78±82.04	209.74±10.25	0.914
Urea (mg/dl)	16.18±4.21	14.52±4.94	0.498
Creatinine (mg/dl)	0.96±0.16	0.92±0.16	0.168

Table 4) Comparison of walking status based on the cut point of Berg Balance Scale between study groups (n=70 in each group; Numbers in parentheses are percentages)

Variables	Score	Diabetic patients	Healthy people	p-value
Need a wheelchair	<20	0 (0)	0 (0)	1.00
Need for assistance in walking	21-40	9 (12.9)	5 (7.1)	0.021
Independent walking	>40	61 (87.1)	65 (92.9)	0.001

Berg Balance Scale score (p=0.001), knee extensor of the dominant foot (p=0.001), knee flexor of the dominant foot (p=0.021), dorsiflexor of the dominant foot (p=0.011), knee extensor of the non-dominant foot (p=0.001), non-dominant knee flexor (p=0.001), and non-dominant foot dorsiflexor (p=0.001), were lower in diabetic patients than healthy people. However, the strength of plantar flexor of the dominant foot (p=0.001) and plantar flexor of the non-dominant foot (p=0.001) in diabetic patients was more than that of healthy people (Table 5).

In the comparison of diabetic patients with polyneuropathy and without neuropathy, the mean score of Berg balance test (p=0.308), the strength of the knee extensor of the dominant foot (p=0.449), knee flexor of the dominant foot (p=0.639), knee flexor of the non-dominant foot (p=0.790), dorsiflexor of the non-dominant foot (p=0.391) did not differ in the two groups. But the strength of the plantar flexor of the dominant foot (p=0.001), the knee extensor of the non-dominant foot (p=0.001), and the plantar flexor of the non-dominant foot (p=0.001) were more in diabetic patients without neuropathy, while the dorsiflexor of the foot was more (p=0.021) in diabetic patients with neuropathy than without neuropathy (Table 6).

Table 5) Comparison of the mean score of the Berg Balance Scale and the strength of the lower limb muscles in two groups (n=70 in each group)

Variable	Diabetic patients	Healthy people	p-value
Berg Balance Scale score	43.5±5.25	50.1±3.22	0.001
Knee extensor of the dominant foot	14.68±3.89	19.38±5.19	0.001
Knee flexor of the dominant foot	14.21±1.64	16.48±2.52	0.021
Plantar flexor of the dominant foot	15.42±2.50	10.81±1.20	0.011
Dorsiflexor of the dominant foot	11.19±3.69	14.52±4.25	0.001
Knee extensor of the non-dominant foot	13.25±3.30	19.46±3.33	0.001
Knee flexor of the non-dominant foot	12.03±1.67	14.98±2.46	0.001
Plantar flexor of the non-dominant foot	13.44±2.21	10.98±2.44	0.001
Dorsiflexor of the non-dominant foot	11.05±2.07	12.85±2.11	0.001

In summary, functional balance and strength of some lower limb muscles were not different in the two groups of diabetic patients, or it was lower in patients with diabetic polyneuropathy. But contrary to expectation, the dorsiflexor strength of the dominant foot was increased in patients with diabetic polyneuropathy.

Table 6) Comparison of the mean score of the Berg Balance Scale and the strength of the lower limb muscles in diabetic patients with neuropathy (n=30) and without neuropathy (n=40)

Variable	Diabetic patients without neuropathy	Diabetic patients with neuropathy	p-value
Berg Balance Scale score	44.7±5.15	42.1±2.07	0.308
Knee extensor of the dominant foot	15.18±5. 29	14.27±4.09	0.449
Knee flexor of the dominant foot	14.48±2.77	13.88±1.22	0.639
Plantar flexor of the dominant foot	16.21±2.46	13.51±2.78	0.001
Dorsiflexor of the dominant foot	10.12±4.33	12.02±3.15	0.021
Knee extensor of the non-dominant foot	14h.21±4.25	12.02±2.20	0.001
Knee flexor of the non-dominant foot	12.90±2.16	12.08±1.46	0.790
Plantar flexor of the non-dominant foot	15.68±2.71	12.21±3.01	0.001
Dorsiflexor of the non-dominant foot	11.35±2.42	10.75±2.00	0.391

Discussion

The present study was conducted with the aim of comparing the balance and strength of the lower limb muscles of diabetic patients with healthy individuals. In this study, unlike most previous studies, the role of neuropathy has been investigated as a secondary objective. The results of the present study showed that the dynamic balance in diabetic patients was lower than the healthy group. In addition, the need for assistance in walking was more in the group of patients with diabetes than in healthy individuals, and independent walking was less in the group of patients with diabetes than in the healthy group. In the comparison of two groups of diabetic patients with neuropathy and without neuropathy, there was no difference in functional balance. The strength of the flexor and extensor muscles, except the plantar flexor, was lower in diabetic patients than in healthy individuals. The strength of the flexor and extensor muscles in all cases except for the dominant foot dorsiflexors was lower in diabetic patients with polyneuropathy than those without neuropathy.

In various studies, a reduction in the quality of spatio-temporal walking parameters such as speed, stride length, walking cycle time, or support time has been shown in diabetic patients with or without polyneuropathy compared to healthy individuals. In these studies, the increase in variety of walking, lower reaction speed, less movement and strength in walking, and the need for more help and care in walking have been expressed [17, 18]. In a study, Donoghue *et al*. showed that walking disorders occur in diabetic patients without neuropathy, and diabetic patients show walking defects long before the objective loss of sensation in the legs [17].

In the present study, the score of the Berg Balance Scale was higher in healthy people than in diabetic patients. In line with the results of the present research, Brown *et al*.'s study [18] reported a significant drop in dynamic and functional balance and various aspects of daily activity of diabetic patients. In the study of Tsai *et al*. [19], functional balance was lower in the group of patients with diabetes than in the group without diabetes. Also, similar to the results of the present study, in the study of Arani *et al*. [20], the mean score of the Berg test was lower than that of the control group, and there was a positive relationship between getting up and moving with age, daily activity, walking power and proprioception. On the other hand, a negative relationship was observed between the Berg test and orthostatic hypotension, proprioception and walking power. In the present study, although the measurement of these relationships was not expected, but muscle strength and dynamic balance were lower in patients with diabetes than in healthy individuals, and it can be said that these two variables are correlated.

The results of the present study showed that in patients with diabetes, the strength of the lower limb muscles was lower than that of healthy subjects in all cases, except for the strength of the plantar flexor of the dominant foot and the plantar flexor of the non-dominant foot, which was lower in healthy subjects than in patients with diabetes. It was found that the functional balance and strength of some lower limb muscles in the two groups of diabetic patients with and without neuropathy were either not different or less in patients with diabetic polyneuropathy. But contrary to expectation, the dorsiflexor strength of the dominant foot was increased in patients with diabetic polyneuropathy.

In line with the results of the present research in the study of Sarabzadeh *et al*. [21], there was a significant difference between the short-term diabetes group and the control group in the transmission of the peroneal nerve and median nerve. Also, a significant difference was observed between the long-term diabetes group and the control group in the peroneal nerve and median nerve, and in the electrical activation of the biceps muscle and the electrical activation of the gastrocnemius. Among these findings, the most important difference between the short-term and long-term diabetic groups was observed in the electrical activation of gastrocnemius and biceps muscle, which ultimately caused a decrease in dynamic balance in diabetic patients [21]. As in the present study, the balance and muscle strength of the legs showed a significant difference in the majority of indicators in diabetic patients compared to healthy people. However, there was no significant difference in Berg Scale score, knee extensor of the dominant leg, knee flexors of the dominant leg, knee flexors of the non-dominant leg and dorsiflexor of the non-dominant leg between diabetic patients with and without neuropathy.

In the study of Wang *et al*. [22], similar to the present study, it was found that the skeletal-muscular components are destroyed with muscle atrophy, reduced joint mobility and uneven force on the soles of the feet. Atrophy of small muscles, such as the extensors of the toes, directly affects the stability of the joints and the strength of the leg muscles. Also, the increase in the size of the Achilles tendon, and the abnormal structure of the tendon and the decrease in dorsiflexion of the ankle lead to an increase in plantar ulcers. In the study of Nomura *et al*. [23], the relative strength of knee extensor muscles was significantly reduced in diabetic patients with neuropathy. As in the present study, the relative strength of knee extensor muscles in diabetic patients was lower than in healthy individuals, and in patients with neuropathy it was lower than without neuropathy.

In diabetic patients, ischemic peripheral nerve damage caused by microvasculopathy of all sensory, motor and autonomic nerve fibers is considered an important factor in causing specific changes, especially in the ankle. Researchers believe that initially these changes start from the lower distal part of the feet, and this also leads to impaired walking and even a greater chance of foot ulcers and, finally, the risk of falling and tripping in diabetic patients. On the other hand, as a result of these events, structural changes such as intrinsic muscle atrophy, increased metatarsal prominence, decreased joint-tendon mobility, and deformity of the forefoot occur in diabetic patients. And finally, the collagen bands turn the smooth tissues into an inelastic shape and cause stiffening of the joints and Achilles tendon, pressure on the front of the foot, and limitation of the movement of the joint in the foot, resulting in an increase in pressure on the sole of the foot and susceptibility to foot ulcers in diabetic patients with and without neuropathy [24-26].

In several studies, distal muscle weakness and atrophy have been shown to be related to the severity of neuropathy [27, 28], and it has been said that obese patients with diabetes have a greater amount of non-contractile intramuscular tissue, which is closely related to insulin resistance and decreased muscle strength in leg and thigh muscles [29]. Changes in muscle mass may contribute to changes in muscle strength, and since many patients with diabetes are obese, they may have larger muscle size but more muscle atrophy due to diabetic neuropathy. In line with the results of the present study, several studies have shown a decrease in muscle strength in knee extension and ankle plantar flexion in diabetic patients with neuropathy compared to the healthy group [30, 31].

Contrary to the results of the present study, in the study of Jeong *et al*. [32], plantar flexion and ankle flexion in people with diabetic neuropathy were less than healthy people, but in Hastings *et al*.'s study [33], a greater difference was recorded. The difference between these two studies is probably due to the progression of the movement disorder of the foot and ankle or the worsening of the foot pathology, and on the other hand, it is related to the selected samples and the method of measuring muscle strength, so that these studies included a group with a proven abnormality of the middle column of the foot. In general, it was expected that the strength of all knee and leg muscles in diabetic patients with neuropathy is less than diabetic patients without neuropathy. This difference is probably related to the significant loss of muscle strength in diabetic patients with neuropathy and the subsequent biomechanical abnormality of the foot and ankle and its effect on increasing the power of plantar flexion of the foot. But, no reliable study was found in this regard.

The possible reasons for the difference between the mentioned studies and the present study can be the difference in the range of selected patients in terms of having or not having diabetic polyneuropathy, the method of measuring muscle strength, the duration of diabetes, the type of drug used, and the number of samples. Vitamin D deficiency is also very common in patients with diabetes, and proximal myopathy is one of the main manifestations of severe vitamin D deficiency. Vitamin D deficiency is associated with atrophy of skeletal muscle fibers type 2 and decreased muscle strength [34], which should be considered in the interpretation of the study results.

Among the limitations of this research, we can mention the available sampling, the small number of samples, the imbalance in the number of samples between the groups with and without neuropathy, and the lack of control over the lifestyle of the research samples, including their physical activity and daily nutrition.

The results of this study also have applications. According to the results, diabetic patients have balance problems and weakness in the muscle strength of the lower limbs, which increases the possibility of falling and injury, and as a result, diabetic foot ulcers. Therefore, interventions such as occupational therapy can be designed to help restore balance, increase the muscle strength of patients, and reduce the chance of these injuries.

It is suggested to compare patients with and without diabetic polyneuropathy independently and with a larger number of samples in future studies. In addition, the patients' lifestyle, such as their diet, exercise, and vitamin D level, should also be examined and controlled.

Conclusion

Dynamic balance and strength of flexor and extensor muscles, except plantar flexor, are lower in diabetic patients than healthy people. The strength of flexor and extensor muscles in all cases, except for the dorsiflexors of the dominant foot, is lower in diabetic patients with polyneuropathy than without neuropathy.

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Ethical Permission: This study was approved and implemented by obtaining the ethics code IR.ARAKMU.REC.1400.251 from the Research Ethics Committee of Arak University of Medical Sciences. Informed consent was obtained from all patients and healthy subjects. It was also emphasized on maintaining the confidentiality of information and the patient's withdrawal at any stage of the research that they wished, and the referral of severe cases to related clinics.

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