

## Efficacy of Exercise Rehabilitation Program in Improving Gait of Diabetic Neuropathy Patients

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### Abstract

**Background:** Gait characteristics are altered in diabetic patients with peripheral neuropathy and little is known about possible treatment strategies. This study evaluates the effect of a rehabilitation program on gait of diabetic peripheral neuropathy patients.

**Methods:** Thirty patients with diabetic peripheral neuropathy were randomly divided into an intervention (n=15) and control groups (n=15). The intervention consisted of an exercise program including range of motion, muscle strengthening, balance, and gait training exercises (3 days weekly over 8 weeks). Controls received only usual recommended medical care. Spatiotemporal parameters and ankle joint range of motion during the stance phase of gait were measured at baseline and after intervention.

**Results:** The intervention program increased significantly walking speed, cadence and ankle range of motion with significant decrease of step time ( $p < 0.05$ ), while for the control group, no significant differences were noted ( $p > 0.05$ ).

**Conclusion:** Selected exercise program can improve gait speed, cadence, step time and ankle joint range of motion in diabetic patients. Future studies are needed to explore the influence of these results on clinical assessment, muscle function and quality of life.

**Key Words:** Diabetic mellitus – Exercises – Gait – Peripheral neuropathy.

### Introduction

ACCORDING to international diabetes federation (IDF) at 2012, Egypt has 7.5 million diabetic patients which occupies the 8<sup>th</sup> level global wide in the top ten countries of people with diabetes [1]. This increase in the prevalence of diabetes mellitus in both men and women represents a major public health problem.

Diabetic peripheral neuropathy (DPN) is one of the most common complications in the progression

of diabetes mellitus. The prevalence of DPN ranges from 13 to 68% of diabetes populations [2].

Patients with diabetes and peripheral neuropathy have a high incidence of injuries during walking. They are 15 times more likely to report experiencing a fall-related injury (fracture, sprained ankle, cuts and bruises) during standing and walking when compared to people without diabetes. In addition, peripheral neuropathy is a risk factor for developing plantar ulcers. Most of these ulcers are thought to develop during walking [3].

Peripheral neuropathy is a progressive degeneration of the peripheral nerves, especially in the lower limbs [4], that affects the sensory, motor, and autonomic components of the peripheral nerves, manifesting as a loss of protective sensation, intrinsic foot muscle dysfunction and anhydrosis of the foot [5].

It has been postulated that DPN-related changes in the lower limbs may lead to functional gait variations; predominantly related to reduced range of movement of joints, reduced active muscle power and changes in gait mechanics including reductions in spatiotemporal parameters, increases in kinetics, and reductions in kinematics of the lower limb (evident as restrictions in the sagittal plane) [6,7]. In addition to altered dynamic electromyography (EMG) findings [8].

Reduced muscle strength around the ankle joint, especially tibialis anterior, may be responsible for the gait deviation of diabetic patients. Tibialis anterior muscle is innervated by peroneal nerve, which is the first nerve to show electrophysiological alterations in patients with diabetic motor neuropathy [9-11]. Moreover, lack of sensorial and kinesthetic information from the ankle, will impair gait [12].

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Reduced strength of ankle plantar flexion has lead to the adoption of a “hip strategy” of walking, whereby the leg is pulled forward from the hip using the hip flexor muscles (hip strategy), rather than being pushed forward by the foot using plantar flexor muscles (ankle strategy). The altered gait strategy suggests that diabetic subjects adopt a “slowness strategy” [12,13].

The technology that supports human motion analysis has advanced dramatically in the past two decades. Motion systems are of many varieties and software is abundantly available for measuring and recording particular body areas or whole systems during a variety of activities [14]. Gait analysis can provide a good objective and quantifiable evaluation of function in diabetic peripheral neuropathy.

The role of physiotherapy in diabetic care is to reduce immobilization effects, maintain functional capacity and minimize diabetes-related complications. The physiotherapist also has a role in providing advice about exercise and daily living activities, this will reflect on improving quality of life while diminishing health care burden [15]. Moreover, the Public Health guidelines for diabetes management recommend that patients perform at least 30min of physical activity a day, six times a week, acquiring adequate gait security and balance [16].

It has been observed that the strength of the lower limb muscles can be improved through a specific muscles-strengthening program in healthy adults, by progressively increasing resistance [17]. Considering DPN patients, most of the previous studies conducted for the assessment of different rehabilitation protocols had focused on generalized muscle strengthening, and balance training [18-20] without the specificity of selecting the most impaired muscle groups due to the neuropathy; the ankle and foot intrinsic muscles. A specific strengthening program for these muscle groups (intrinsic and extrinsic foot muscles), associated with range of motion, have not been studied adequately.

The concept of considering how the diabetic disease process affects not only the foot but the movement pattern of the entire lower extremity is fundamental in order to determine the most optimal treatment approach for these patients and to develop more focused intervention strategies. Therefore, this study aimed to assess the effect of a selected exercise program on gait (spatiotemporal parameters and ankle joint range of motion during the stance phase of gait), in patients with diabetic peripheral neuropathy.

## Subjects and Methods

A total of 30 patients were recruited from Out-patient clinic of Diabetes, Faculty of Medicine and Outpatient Clinic, Faculty of Physical Therapy, Cairo University, with a diagnosis of diabetic peripheral neuropathy confirmed by an abnormal nerve conduction study. Eligible patients included patients with age ranged between 50 to 65 years, type 2 diabetes mellitus diagnosed for at least 7 years [21], and presence of DPN previously diagnosed by a physician. Eligibility criteria also included a score higher than 2 out of 13 in the questionnaire of the Michigan Neuropathy Screening Instrument [22,23] indicating the presence of at least two DPN symptoms, body mass index ranging between 25 and 34.9kg/m<sup>2</sup> (overweight and class one obesity) and ability to walk independently in the laboratory space. Patients were excluded from the study if they have unstable glycemic control and/or medical conditions that would confound assessment of neuropathy such as malignancy, active/untreated thyroid disease, other neurological or orthopaedic impairments (such as stroke, poliomyelitis, rheumatoid arthritis, prosthesis, or severe osteoarthritis), major vascular complications (venous or arterial ulcers), severe retinopathy, or severe nephropathy that causes edema or needs haemodialysis. The participants were randomly allocated into an intervention group and a control group using sealed envelope with 15 patients in each group. During the study period, both groups continued to receive the usual recommended medical care, which included pharmacological treatment and self-care instructions. The use of analgesics was allowed, but had to be unchanged for at least four weeks before entering the study and during the study. The intervention group only had received an exercise program. The study was conducted at Faculty of Physical Therapy, Cairo University from June 2013 – June 2014.

### *Assessment:*

#### *Clinical assessment:*

Each assessment consisted of history taking regarding diabetes history, and any other health issue of interest. The Michigan Neuropathy Screening Instrument (MNSI) questionnaire and physical assessment were used to characterize the signs and symptoms, and to monitor the disease status. The MNSI consists of 15 “yes or no” questions on foot sensation (pain, numbness, and sensitivity to temperature), including one relevant to general asthenia and one relevant to peripheral vascular disease, and was administered to all patients. The questions of MNSI questionnaire were thought to reflect

common symptoms reported in DPN together with two questions to record non-neuropathic and primarily vascular manifestations [22,23]. Intrinsic and extrinsic foot and ankle muscle functions were assessed through manual muscle testing [24].

#### *Electrophysiological assessment:*

The Toennis Neuroscreen Plus device (made in Germany) was used to measure peroneal motor conduction velocity (P MCV), amplitude and sural sensory conduction velocity (S SCV). Conventional nerve conduction studies (NCSs) were administered using a standard testing protocol. Studies included testing of bilateral peroneal and sural nerves. All measurements were done under a standard room temperature of 25°C. The skin temperature of the leg was maintained at 37°C.

Peroneal nerve MCV was measured with standard surface electrodes with distal stimulation just lateral to the tibialis anterior tendon (about 8cm proximal to the active pickup electrode) and proximal stimulation was applied just below the head of the fibula, with the recording electrode over the extensor digitorum brevis and the earth electrode was positioned mid-calf [25].

Sural nerve SCV was measured with the active pickup electrode placed posterior and below the lateral malleolus of the fibula; the reference electrode was placed 3cm distal to the active electrode and the earth electrode positioned between the cathode of the stimulator and the active pickup electrode. Stimulation was applied slightly lateral to the midline in the lower third of the posterior aspect of the leg with the cathode distally about 17cm from the active electrode [25].

#### *Gait assessment:*

Gait was assessed at baseline condition and after the intervention period for both groups. It was conducted in Gait Analysis Lab, El-Agoza Military Rehabilitation Center. Qualisys Motion Capture System was used to measure Kinematic gait parameters. Kinematic gait parameters were acquired using three dimensional displacement of passive reflective markers (20mm in diameter) tracked with 8 infrared cameras [26]. The markers were placed on the following special bony landmarks of the patient's body on both sides of the body: Anterior superior iliac crest, greater trochanter, superior edge of the patella, lateral aspect of the knee joint line, tibial tuberosity, lateral malleolus, dorsum of foot between the bases of the 2<sup>nd</sup> and 3<sup>rd</sup> metatarsal bones and over the heel (posterior of calcaneus) [27].

The assessor instructed the patients to walk on the walkway inside the lab bare feet at their natural or comfortable walking speed (self-selected speed) [28]. Three to five walks along the walkway were allowed prior to recording of data, so that subjects were familiar to the walkway and then they were asked to begin from the starting position which was determined during the test trials and when they passed the starting position, the Qtrac measurement was started and they were let to continue walking until several meters after the volume to allow the Qtrac measurement to be completed.

The variables to be analysed were (1) Spatio-temporal (distance and time) parameters which included: Walking velocity (m/sec), cadence which is the number of steps per minute (steps/min) [29], step time which is the time between two consecutive heel strikes (sec), and Double limb support which is the time over which the body is supported by both legs (sec). (2) Ankle joint range of motion during the stance phase of gait which is the phase when the foot is on the ground [21,28].

#### *Exercise intervention:*

The patients allocated to the intervention group received the treatment for 8 weeks, three times a week, 45-60min per session. The therapeutic sessions were divided into four types of exercises: (1) Range of motion exercises (ROM), (2) Muscle strengthening exercises, (3) Balance exercises, and (4) Gait training exercises.

Gradual and progressive difficulty was offered to the patient, respecting any limitation due to pain and/or decrease in performance during execution. In addition, in each session, the patient performed the exercises following an order that started with the passive exercises, progressed to active, and finished with balance and gait training exercises.

The discontinuation criteria for the exercises during one session were cramps, moderate to intense pain, fatigue, dizziness, or any other condition that exposes the patient to any kind of risk or discomfort [21]. For Each exercise, the patient should perform the complete number and duration before progressing to the more difficult one.

Exercise intervention included the following exercises:

#### *1- Range of motion (ROM) exercises:*

- Passive stretching of flexors and extensors of toes, hallux and stretching of calf and hamstring muscles [30] that performed from long sitting position, with knees extended and ankle

in neutral. Flexion and extension of the toes and hallux were done separately.

- Each stretching exercise was done for 3 repetitions x30 seconds holding time each.
- Range of motion exercises progressed through all the sessions until full ROM obtained and done with free pain.

### 2- Muscles strengthening exercises:

- Muscle strengthening of toes flexor muscles, and foot intrinsic muscles from supine lying position with manual resistance and from sitting with the foot flat on the floor and catch an object with the toes.
- Muscle strengthening of toes extensor muscles from supine lying position with manual resistance and sitting with the foot flat, extension of the toes, no dorsiflexion was allowed.
- Flexors, extensors, invertor and evertor muscles of the foot and ankle from supine lying position with manual resistance and from standing on heels and toes.
- These exercises were performed for 1x30 repetitions except standing on heels and toes 1x20 repetitions [21,31].

### 3- Balance training:

- Standing with single leg support with or without upper limb support according to the patient tolerance.
- Standing with double leg support on the balance board.
- Standing on heels and toes.
- These exercises were performed for 3 times, each for 30sec.
- Balance training started by opened then closed eyes [31].

### 4- Gait training:

- Walking over the heels, toes, lateral border, and medial border of feet with the preferred speed.
- Walking in tandem.
- If necessary, the patient can intercalate tasks. Patient continued to progress his walking distance until reaching 30 meters of each task without need for rest [21].

### Ethical considerations:

This study was approved by the Ethical Committee of the Faculty of Physical Therapy, Cairo University. The study procedures were explained

and written informed consent was obtained from eligible participants.

### Statistical analysis:

Statistical analyses were performed using SPSS Version 20 for Windows (SPSS, Chicago, IL, USA). The two tailed Student's *t*-test (for paired and unpaired values) was used to compare within and between both groups for quantitative data. Chi square test was used for analyzing categorical data. Statistical significance was established at  $p \leq 0.05$  level.

## Results

This study was conducted on 30 patients with DPN. Fifteen patients were engaged in an exercise program for 8 weeks and another 15 patients served as a control group. The demographic data shown in Table (1) revealed that there was no significant difference between groups concerning age, sex, weight, height, BMI, duration of diabetes, MNSI, nerve conduction velocity (NCV) of common peroneal and sural nerves and amplitude of common peroneal nerve as *p*-values were  $>0.05$ .

Table (1): Demographic data of the patients (intervention and control groups).

| Variables                      | Intervention group | Control group | <i>p</i> value |
|--------------------------------|--------------------|---------------|----------------|
| Age (years)                    | 56.7±0.3           | 57.7±4.2      | 0.502          |
| Sex ( Male/Female)             | 6/9                | 7/8           |                |
| Sex %                          | 60/40              | 46.7/53.3     | 0.715          |
| Weight                         | 85.6±6.2           | 87.3±4.6      | 0.478          |
| Height (cm)                    | 167.2±8.2          | 169.7±2.6     | 0.389          |
| BMI (Kg/m <sup>2</sup> )       | 30.7±3.6           | 30.5±1.4      | 0.806          |
| DM Duration (years)            | 14.73±3.8          | 15.4±1.8      | 0.547          |
| MNSI                           | 4.5±2.1            | 4.9±1.6       | 0.639          |
| Common peroneal NCV (m/s)      | 46.1±3.3           | 45.3±4.4      | 0.09           |
| Common peroneal amplitude (mA) | 1.71±0.26          | 1.8±0.37      | 0.574          |
| Sural NCV (m/s)                | 33.07±1.9          | 33.5±2        | 0.635          |

BMI : Body mass index.

DM : Diabetes mellitus.

MNSI: Michigan Neuropathy Screening Instrument.

NCV : Nerve conduction velocity.

### Spatiotemporal parameters:

Regarding spatiotemporal parameters, no statistically significant difference ( $p > 0.05$ ) was found between the groups at pretreatment measurement, as shown in Table (2). In the intervention group, walking velocity, cadence were increased significantly ( $p = 0.017$ , and  $0.001$  respectively) with percentage of change were 22.54% for velocity and 8% for cadence. In addition, step time was



significantly decreased ( $p=0.031$ ) with percentage of change was ( $-26.7\%$ ). However, no significant change in double support time had occurred ( $p=0.343$ ), (Table 3). While in the control group, there was no significant change in any of the measured variables ( $p=0.228, 0.866, 0.136$  and  $0.812$  respectively), (Table 4). Post-treatment measurement comparison between groups found a significant difference in walking velocity and step time ( $p=0.017, 0.03$  respectively) in favor of the intervention group, with non significant change in cadence and double support time ( $p=0.236$  and  $0.187$  respectively) (Table 2 and Figs. 1,2,3).

#### Kinematic parameters:

At pre-treatment measurement, no significant difference was found between the groups in ankle range of motion during the stance phase of gait, ( $p>0.223$ ), (Table 2). In the intervention group, ankle range of motion was increased significantly ( $p=0.002$ ) with percentage of change was  $5.5\%$ ; while in the control group, no significant change was noted ( $p=0.813$ ), (Tables 3,4). Comparing the post-treatment results of the two groups, significant difference was found ( $p=0.008$ ), in favor of the intervention group, (Table 2 and Fig. 4).

Table (2): Statistical analysis of spatiotemporal parameters and ankle range of motion of stance phase pre and post treatment, for both groups.

| Variables                     | Pre measurement |            |                 | Post measurement |            |                 |
|-------------------------------|-----------------|------------|-----------------|------------------|------------|-----------------|
|                               | Intervention    | Control    | <i>p</i> -value | Intervention     | Control    | <i>p</i> -value |
| Velocity (m/s)                | 0.71±0.07       | 0.7±0.02   | 0.563           | 0.87±0.18        | 0.73±0.04  | 0.017*          |
| Cadence (steps/min)           | 82.9±8.2        | 85.3±2.12  | 0.336           | 89.5±11.2        | 85.5±3.9   | 0.236           |
| Step time (s)                 | 0.86±0.17       | 0.80±0.06  | 0.360           | 0.63±0.19        | 0.82±0.04  | 0.03*           |
| Double support time (s)       | 0.46±0.09       | 0.4±0.06   | 0.204           | 0.44±0.08        | 0.4±0.02   | 0.187           |
| Ankle ROM of stance phase (°) | 19.38±2.39      | 18.56±0.73 | 0.223           | 20.45±2.16       | 18.62±0.96 | 0.008*          |

Data are presented as mean±standard deviation.

m: Meters. s: Seconds. °: Degrees. \*: Significant.

ROM: Range of motion.

Table (3): Statistical analysis of spatiotemporal parameters and ankle range of motion of stance phase in intervention group.

| Variables               | Pre        | Post       | % of change | <i>p</i> value |
|-------------------------|------------|------------|-------------|----------------|
| Velocity (m/s)          | 0.71±0.07  | 0.87±0.18  | 22.54%      | 0.017*         |
| Cadence (steps/min)     | 82.94±8.2  | 89.5±11.21 | 8%          | 0.001*         |
| Step time (s)           | 0.86±0.17  | 0.63±0.19  | -26.7%      | 0.031*         |
| Double support time (s) | 0.46±0.09  | 0.44±0.08  | -4.34%      | 0.343          |
| Ankle ROM of stance (°) | 19.38±2.39 | 20.45±2.16 | 5.5%        | 0.002*         |

Data are presented as mean ± standard deviation

m : Meters. ° : Degrees.

s : Seconds. \*: Significant.

ROM : Range of motion.

Table (4): Statistical analysis of spatiotemporal parameters and ankle range of motion of stance phase in control group.

| Variables               | Pre        | Post       | % of change | <i>p</i> value |
|-------------------------|------------|------------|-------------|----------------|
| Velocity (m/s)          | 0.7±0.02   | 0.73±0.04  | 4.3%        | 0.228          |
| Cadence (steps/min)     | 85.3±2.12  | 85.5±3.9   | 0.23%       | 0.866          |
| Step time (s)           | 0.80±0.05  | 0.82±0.04  | 2.5%        | 0.136          |
| Double support time (s) | 0.4±0.06   | 0.4±0.02   | 0%          | 0.812          |
| Ankle ROM of stance (°) | 18.56±0.73 | 18.62±0.96 | 0.32%       | 0.13           |

Data are presented as mean ± standard deviation.

m: Meters. ROM : Range of motion.

s : Seconds. ° : Degrees.

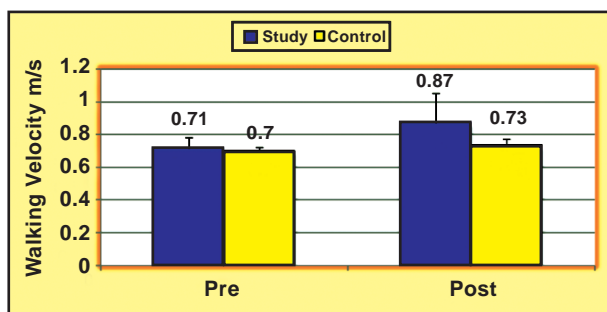


Fig. (1): Mean and standard deviation of walking velocity pre and post treatment of both groups.

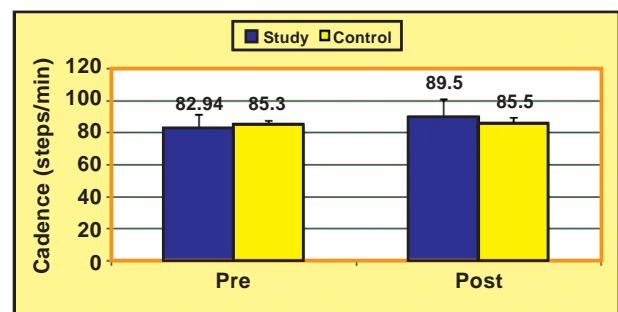


Fig. (2): Mean and standard deviation of cadence pre and post treatment of both groups.

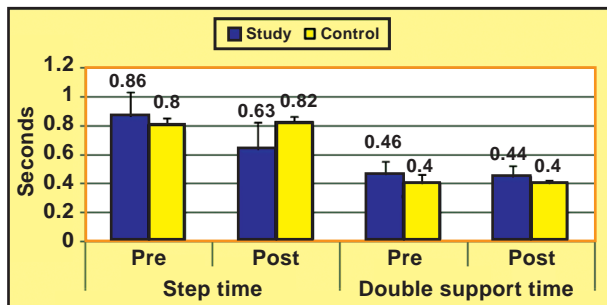


Fig. (3): Mean and standard deviation of step time and double support time pre and post treatment of both groups.

### Discussion

Diabetic peripheral neuropathy (DPN) leads to sensory and motor deficits, which often result in mobility-related dysfunction and alterations in gait characteristics [32,16]. Diabetic patients with peripheral neuropathy have lower gait velocity, decreased cadence, shorter stride length and increased stance time compared with healthy controls [32].

The study reported here evaluated the effect of a training program consisted of range of motion, muscle strengthening, balance, and gait training exercises on selected gait parameters of diabetic patients with peripheral neuropathy. The outcome measurements are spatiotemporal parameters and ankle joint range of motion during the stance phase of gait.

The results of the present study revealed that gait in patients with DPN can be improved by an exercise rehabilitation program. Patients in the intervention group showed an increase in gait velocity, cadence, ankle joint mobility and decreased step time. The Post intervention evaluation showed significant difference between groups for walking velocity, step time and ankle joint range of motion.

The percentage of improvement gained by the intervention group in gait velocity (22.5%) was both significant and clinically relevant. A decrease in gait speed of 0.1m/s in the elderly has been associated with a 10% decrease in the ability to perform daily living activities [33].

Increased ankle strength as well as ankle mobility may explain the progress in spatiotemporal parameters [34]. Also, since the protocol included exercises that involved proximal muscles as well (e.g. walking exercises), the improvement can be a consequence of the improved performance of hip flexors, hamstrings, and quadriceps muscles which were trained during the walking exercises. Ankle

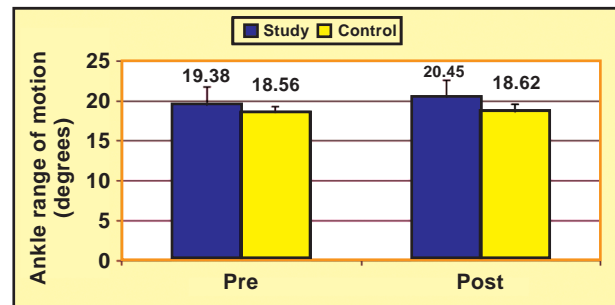


Fig. (4): Mean and standard deviation of ankle range of motion during stance phase pre & post treatment of both groups.

and toes movements are expected to become impaired throughout the course of the disease. Training these functions preventatively may slow down the prognosis of the diabetes chronic complications [35] and the gain in these functions can further explain the results.

Only few studies have evaluated treatments that aim to improve gait. Richardson et al., 2004 [36], evaluated patients with various forms of peripheral neuropathy and they found that the use of a cane, ankle orthoses or touching a wall improved step-width range, step-time variability and speed while walking under challenging conditions.

Petrofsky et al., [37] tested an insulin sensitiser, rosiglitazone, which promises to reverse some of the circulatory impairments seen in diabetes, thereby improving patients' gait. They reported encouraging results after administering rosiglitazone (decreased step width and less acceleration at the joints). However, rosiglitazone was recently associated with increased risk of myocardial infarction and death from cardiovascular incidents [38].

Orr et al., [19] and Tsang et al., [20] have investigated the effect of a specific physical training program on habitual and maximal walking speed. However, both studies seem to have evaluated the same group of participants. In these studies, the effect of a "Tai Chi for Diabetes" program (twice a week for 16 weeks) on gait, balance and musculoskeletal fitness was compared with that of sham exercises. Gait speed and balance improved, but no significant differences between groups were reported. All of these studies studied different interventions other than localized exercises.

Moreover Allet et al., [34] studied the intervention effect consisted of physiotherapeutic training, including gait and balance exercises with function orientated strengthening (twice weekly over 12 weeks). Their study was one of the first randomized controlled trials to describe an effective exercise

training program geared to concurrently improving the balance and gait of diabetic patients. Although the improvement of ankle dorsal flexor strength and ankle dorsiflexion mobility failed to be significant, walking speed and ankle plantar flexor strength significantly improved which supports our spatiotemporal results.

Also Sartor et al., [35] evaluated the effect of combination of stretching, strengthening, and functional foot and ankle exercises (twice a week over 12 weeks) on foot function in patients with DPN. The exercise program provided pressure redistribution occurred in foot areas. Although, sagittal ankle range of motion of stance phase failed to reach significant increase within the intervention group (in contrast to our results), it differed significantly from the control group which comes in agreement with current results.

Of concern, our sample was composed of non-severe neuropathy patients, i.e., subjects who have not lost all their sensitivity and muscle functions. This could have been influenced by the criteria of inclusion and exclusion used and must be considered in the clinical decision-making process. Patients with more severe DPN or with more impaired functional capacity may benefit less from training, due to the fact that, from a functional point of view, the detrimental effects of diabetes can't be reversed or compensated. However, the reverse may also be possible; patients suffering from more severe peripheral neuropathy could benefit even more from a structured exercise regimen, as their condition provides more scope for improvement [34]. Moreover, even though gait changes seen in diabetic patients are probably primarily due to neuropathy, there are other potential contributors [39]. Gait impairments are also observed in diabetic patients without clinically detectable neuropathy [32]. Therefore, from the previously mentioned, more researches are needed to test a similar program on patient groups with larger sample sizes differentiated by neuropathy status (patients without, or with severe peripheral neuropathy) in order to prevent further impairment of gait. In addition, outcomes such as functional capacity, the number of falls or quality of life should be considered in order to draw meaningful conclusions about exercise efficacy, thereby facilitating medical and clinical decision-making. The appraisal of advantages, difficulties and feasibility of treatment, as well as follow-up after a period of time may be other interesting issues for further studies.

Lastly, the important role of preventive actions in DPN patients should be highlighted, as complications in muscles and joints occur over the long

term, and it is of great importance to preserve and maintain their integrity. For incipient and moderately impaired patients with DPN, the suggested exercises are easy to perform at home, compared to general purpose exercises that need supervision [40]. Until now, most therapies have been applied only after ulceration and amputation, with relative success; only a few have been studied before such lesions.

### Conclusion:

The current results provide encouraging data that a specific exercise training program including range of motion, muscle strengthening, gait and balance exercises can improve gait of diabetic patients with peripheral neuropathy which justify future studies. To maintain the obtained benefits longer, the periodic repetition of the intervention is recommended.

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