ORIGINAL PAPER

Physiotherapy Quarterly (ISSN 2544-4395)
2024, 32(3), 40–44

Effect of foot muscle energy technique in patients with diabetic neuropathy: a randomized controlled trial

DOI: https://doi.org/10.5114/pq/174937

Radwa Fayek Hammam[1], Ahmed Magdy Alshimy[2], Andrew Anis Fakhrey Mosaad[3], Maha Gamal Ibrahim[1]

[1] Faculty of Physical Therapy, MTI University, Cairo, Egypt
[2] Faculty of Physical Therapy, Al Ryada University for Science and Technology, Sadat city, Menoufia, Egypt
[3] Faculty of Physical Therapy, Merit University, Sohag, Egypt

Abstract

Introduction. This study investigated the effect of foot muscle energy technique (MET) on nerve conduction velocity (NCV) and isometric muscle strength in patients with type 2 diabetic neuropathy (DN).

Methods. Forty-four patients were randomly assigned to either the MET group (group A) or the conventional physical therapy program group (group B). Electrophysiological measurements, including peroneal and tibial motor NCV studies, and isometric muscle strength using a toe strength dynamometer, were conducted. The assessment period ranged from April to November 2022, with measurements taken before the first session and after 4 weeks of treatment.

Results. Significant improvements were observed in post-treatment peroneal motor NCV ($p < 0.001$), tibial motor NCV ($p < 0.001$), and isometric muscle strength ($p < 0.001$) in group A, but not in group B.

Conclusions. MET enhances motor NCV and isometric muscle strength in patients with type 2 DN.

Key words: diabetic neuropathy, foot muscle energy technique, isometric muscle strength, motor nerve conduction velocity study

Introduction

An important global health concern is diabetes mellitus. It is estimated that 628 million people will have this condition by 2045, up from the current 425 million cases [1]. Disorders of the peripheral nervous system (DPN) are those that affect it [2].

Distal symmetric polyneuropathy, one of the most prevalent complications, is usually accompanied by numbness, tingling [3], pain [4], or weakness [5], which spreads up the limb in a stocking distribution [6]. DPN is a leading global cause of disability [7], affecting quality of life due to chronic pain, frequent falls [8], foot ulceration, and limb amputation [9].

Stretching of shortened structures, increasing range of motion (ROM), and treating trigger points in a variety of musculoskeletal conditions are achieved by applying the foot muscle energy technique (MET). MET frequently involves brief durations of isometric muscular contraction, which affect the Golgi tendon organs and result in post-isometric relaxation [10].

By combining creep and plastic changes in connective tissue, MET lengthens muscles. This occurs due to a shift in biomechanics, neurological alteration, or increased tolerance during stretching. After using muscle energy procedures, biomechanical and neuro-physiological mechanisms may cause changes in ROM and muscle tension. The neurological component is explained by the suppression of motor activity in muscles that are about to be stretch; the goal of stretching is to diminish muscular activity to lower stretching resistance [11].

In 1989, Greenman described isometric, concentric, and eccentric contractions as types of muscle contraction performed in MET [12]. Therefore, MET is a manual treatment to improve any joint's decreased ROM. This technique can resolve muscle contracture or weakness, and it can reduce localized edema by stimulating rhythmic muscle movements [13]. MET decreases sympathetic tone through fascial stimulation and localized vasodilation. As a result, the patient can perform an isometric contraction and, consequently, experience post-isometric relaxation of the contracted muscle. MET also induces reciprocal agonist muscle inhibition. This phenomenon results from a physiological neuro-response involving Golgi tendon organs [14]. Foot MET is an effective treatment technique in resolving diabetic neuropathy (DN) patients, but there is a lack of evidence that can evaluate the effect of foot MET in patients with DN.

Therefore, the current study aimed to investigate the effect of MET on nerve conduction velocity (NCV) and isometric muscle strength in patients with type 2 DN**.**The hypothesis of the present study suggested that there was no statistically significant effect of foot MET in patients with DN.

Subjects and methods

Study design

A double-blind, randomized controlled trial (RCT) was used. Neither participants nor the investigators were instructed regarding the allocation of groups. Participants were randomly allocated through a secure system of opaque, closed envelopes and divided into group A (received foot MET and conventional physical therapy program) and group B (received conventional physical therapy program only). They received three sessions per week for 4 weeks. G-power 3.1 was used for the prior analysis of this study using the paired and unpaired *t*-test comparisons option. The supposed sample size was 22 patients for each group, totaling 44 patients [15]. The assessment time frame began in April and ended

Correspondence address: Ahmed Magdy Alshimy, Faculty of Physical Therapy, Al Ryada University for Science and Technology, Sadat city, Menoufia, Egypt, e-mail: ahmed.alshimy@rst.edu.eg; https://orcid.org/0000-0002-1997-3473

Received: 10.04.2023
Accepted: 07.11.2023

Citation: Hammam RF, Alshimy AM, Mosaad AAF, Ibrahim MG. Effect of foot muscle energy technique in patients with diabetic neuropathy: a randomized controlled trial. Physiother Quart. 2024;32(3):40–44; doi: https://doi.org/10.5114/pq/174937.

in November 2022, with each assessment conducted before the first session and after 4 weeks of treatment.

Participants

Forty-four type 2 DN patients were selected by neurologists from various hospitals in Cairo, Giza, and 6 October City in Egypt. Participants (males and females) diagnosed with non-insulin-dependent diabetes for ≥ 10 years, as determined by neurophysiological measurements, were enrolled [16]. The participants regularly took their diabetes medications during the assessment and treatment period. Moreover, the use of any sedatives or anticonvulsants was contraindicated for all participants. The exclusion criteria were uncontrolled non-insulin-dependent diabetes diagnosed for < 10 years [17], neural, muscular, and skeletal system deformities, radiculopathy, and psychiatric disorders. Participants were randomly allocated through a secure system of opaque, closed envelopes and divided into group A (received MET and conventional physical therapy program, which includes graduated active resistance exercises for both upper and lower limbs, and graduated gait training) and group B (received conventional physical therapy program only). They received three sessions per week for 4 weeks. Consent forms were obtained from all patients in the recent study. This research adhered to the Consolidated Standards for Reporting Trials (CONSORT) guidelines for reporting the trial, as shown in Figure 1.

Procedure and instrumentation

Assessment procedure

A neurophysiologist performed the electrophysiological measurements for both tibial and deep peroneal motor (NCV) studies. A model of the device was applied for the study (Nihon Kohden, Japan, MEB-9200/9300). 1 – Tibial motor NCV studies involved placing an active electrode on the abductor hallucis brevis muscle. Stimulating electrodes were positioned at two locations (ankle and popliteal fossa), with an earth electrode placed between the stimulator cathode and the active pickup electrode. A reference electrode was placed over the metatarsal-phalangeal joint of the big toe. 2 – The deep peroneal motor NCV study was conducted by placing stimulating electrodes at two sites (beneath the fibular head and anterior ankle), an active electrode on the extensor digitorum brevis muscle, a reference electrode distally over the metatarsal-phalangeal joint of the little toe, and an earth electrode positioned between the stimulator and active electrodes [18]. In the toe strength dynamometer, the patient was seated on a chair with their foot flat on the ground and a plastic card placed under the 2nd to the 5th toe. The therapist pulled the toes in a straight line to assess foot strength. This process was repeated for the other foot [19].

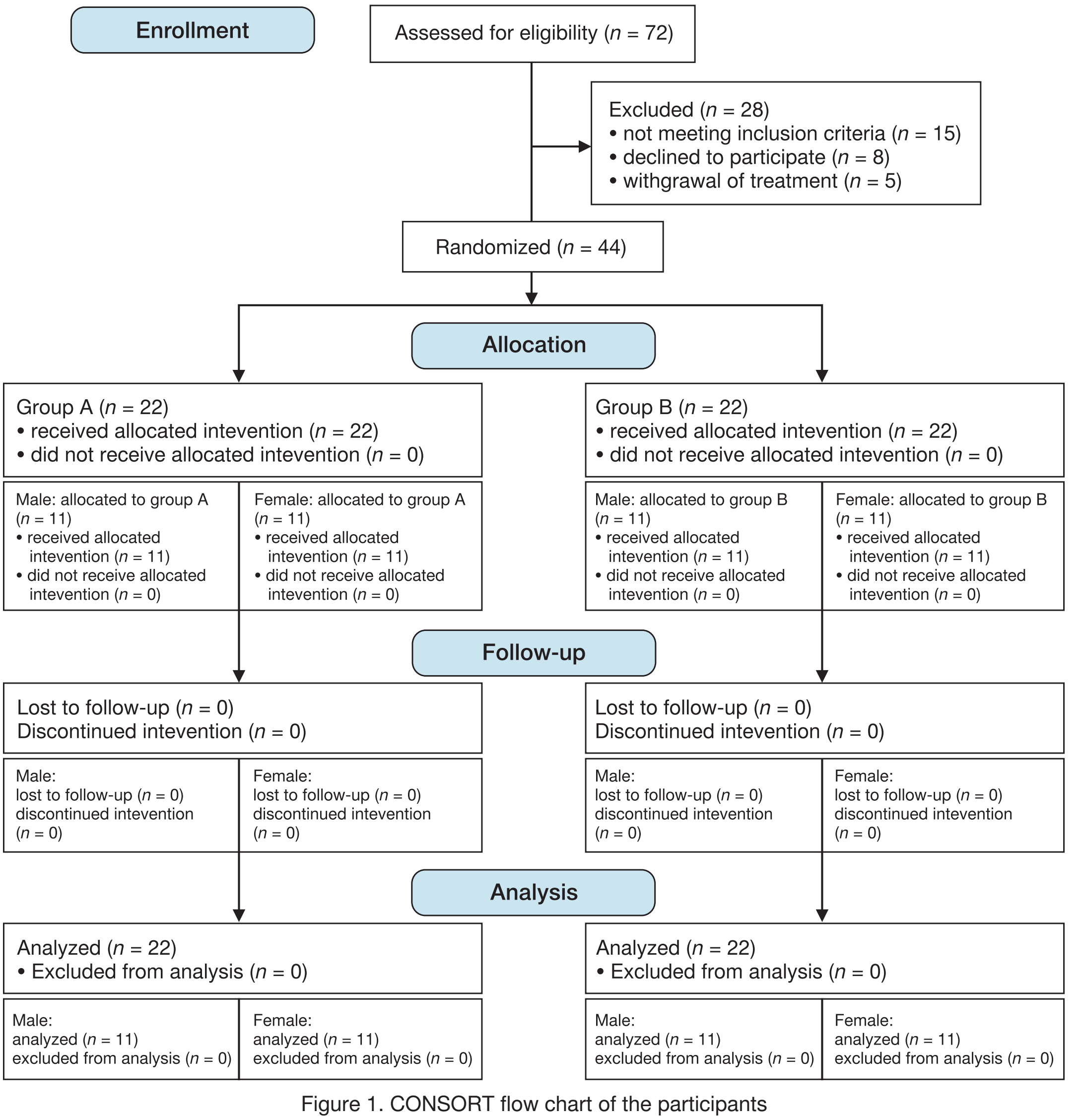

Figure 1. CONSORT flow chart of the participants

Preparation

The patient lay in a supine position with feet outstretched from the bed. The therapist's left handheld the patient just above the ankle with no pressure on the Achilles tendon. The therapist's other hand supported the foot, with fingers on the dorsum and thumb on the sole along the medial aspect, but avoiding the center [20].

Training procedure

Group A

Participants received three sessions per week for 4 weeks, each lasting 30 min. From the initial position, at the restriction barrier, the patient was instructed to exert less than 20% of his strength simultaneously. First, we assessed the patient's foot strength and determined his full strength using the toe strength dynamometer. Second, we calculated 20% of the patient's full foot strength. Third, we taught the patient how to apply 20% of his foot strength using the toe strength dynamometer. Fourth, the patient performed the exercise at 20% of his foot strength, maintaining a proper breathing pattern during plantar flexion movements involving the gastrocnemius or soleus muscles, according to knee position, for 7–10 s with a held breath. The exercise was repeated until the full range of movement was obtained [20]. Conventional physical therapy included graduated active resisted exercises for both upper and lower limbs, and graduated gait training, received three times per week for 4 weeks, with each session lasting 30 min.

Group B

Participants received only the conventional physical therapy program (graduated active resisted exercises for both upper and lower limbs, and graduated gait training) for the same duration as group A.

Outcome measures

Outcome measures included foot muscle energy efficacy for motor NCV study and isometric muscle strength in patients with type 2 DN.

Data analysis

All analyses were performed using SPSS version 24. Descriptive statistics (means and standard deviations) were presented for all variables. Analytical statistics included paired *t*-tests for within-group comparisons and unpaired *t*-tests for between-group comparisons, conducted pre- and post-treatment, under the assumption the data were normally distributed. The chi-square test was used to compare sex distribution between groups. The significance level was set at 0.05.

Results

All patients' baseline characteristics are presented in Table 1. The groups did not differ significantly in baseline characteristics, indicating homogeneous groups ($p > 0.05$).

Within-group comparisons

The mean (± *SD*) values of isometric strength (lbs), peroneal NCV (m/s), and tibial NCV (m/s) pre-treatment were 68.55 (4.4) lbs, 38.22 (3.1) m/s, and 36.82 (4.4) m/s, respectively. Post-treatment values were 79.2 (5.1) lbs, 43.14 (2.7) m/s, and 43.14 (3.07) m/s, respectively, in group A (foot MET + conventional physical therapy program). For group B (conventional physical therapy program only), pre-treatment values were 67.27 (3.56) lbs, 39.15 (3.18) m/s, and 37.4 (4.25) m/s, respectively, and post-treatment values were 69.86 (3.3) lbs, 39.6 (3.15) m/s, and 37.24 (4.25) m/s, respectively, as presented in Table 2.

There were significant improvements in isometric strength, peroneal NCV, and tibial NCV post-treatment in both groups ($p < 0.001$), as shown in Table 2.

Table 1. Baseline characteristics of patients in both groups

Baseline characteristics	Group A (mean ± *SD*)	Group B (mean ± *SD*)	*p*-value
Age (years)	52.2 ± 4.64	51.23 ± 4.82	0.51
Weight (kg)	67.82 ± 2.77	67.68 ± 2.7	0.87
Height (m)	1.71 ± 0.027	1.71 ± 0.026	0.96
BMI (kg/m^2)	23.15 ± 1.04	23.12 ± 1.06	0.92
Sex (male/female)[a]	11/11	11/11	1

[a] count

Table 2. Analytical statistics of isometric strength and NCV (peroneal and tibial nerves) within and between groups

Outcomes	Group A (mean ± *SD*)	Group B (mean ± *SD*)	*p*-value (between groups)
Isometric strength (lbs)			
pre	68.55 ± 4.4	67.27 ± 3.56	0.3
post	79.2 ± 5.1	69.86 ± 3.3	< 0.001*
p-value (within groups)	< 0.001*	< 0.001*	
Peroneal NCV (m/s)			
pre	38.22 ± 3.1	39.15 ± 3.18	0.86
post	43.14 ± 2.7	39.6 ± 3.15	< 0.001*
p-value (within groups)	< 0.001*	< 0.001*	
Tibial NCV (m/s)			
pre	36.82 ± 4.4	37.4 ± 4.25	0.33
post	43.14 ± 3.07	37.24 ± 4.254	< 0.001*
p-value (within groups)	< 0.001*	< 0.001*	

* significant at $p < 0.05$

Between-group comparisons

There were no significant differences in isometric strength and NCV (peroneal and tibial nerves) between groups at pre-treatment ($p > 0.05$). However, significant differences ($p < 0.001$) were observed between groups A and B in isometric strength and NCV (peroneal and tibial nerves) post-treatment, with group A (receiving foot MET) demonstrating superiority, as shown in Table 2.

Discussion

The main aim of the conducted study was to investigate the effect of foot MET on NCV and isometric muscle strength in patients with type 2 DN.

The results revealed a significant improvement in post-treatment peroneal motor NCV, tibial motor NCV, and isometric muscle strength in group A but not in group B.

Long-term DN causes early muscular atrophy in the foot, advances steadily in the lower legs, is correlated with the degree of neuropathy, and results finally in ankle weakness [21]. This consecutively affects function capacity, increasing fall frequency and deteriorating balance. All these adverse effects can be lessened by moderate-intensity exercises according to patient tolerance [22].

Because MET involves voluntary contraction against the therapist's controlled resistance in a definite direction, it helps reduce pain, improve muscle tone, stretch tightened muscles, and strengthen weak muscles, thereby improving local circulation and restoring joint ROM [23].

The current study demonstrates improvements in isometric strength and peroneal and tibial NCV post-treatment in patients with DN after the application of MET, which was more significant than in the control group. The findings of the MET group were supported by Wang et al. [24], who reported that stroke patients with hemiplegia and diabetes improved in terms of pain, balance, and stability after a program combining the neuromuscular activation method with MET, leading to better quality of life.

Furthermore, recent data are conceptually in line with Gad Elhak et al. [25], who demonstrated that MET and active release technique have a positive impact in increasing median motor NCV and hand grip in patients with carpal tunnel syndrome.

Our concept also aligns with Sartor et al. [26], who implemented a program of four stages that progressed from ankle-foot complex ROM exercises to strengthening exercises, functional activities, and gait training. They observed a significant change in foot rollover toward a more physiological process and reported enhanced pressure distribution on the plantar surface and improved functional health.

On the other hand, El-Refay and Ali [27] applied a combination of foot stretching, strengthening, balance, and gait training in patients with DN but found no appreciable improvement in NCS of the common peroneal and sural nerves. Thus, the current study rejects the null hypothesis.

Given the results of the current study, we concluded that treatment with MET is effective in improving NCV parameters and isometric muscle strength in patients with DN compared to conventional physical therapy alone. These results suggest that treatment using MET is a useful, effective, and non-invasive approach for treating patients with DN. In the future, we hope that all physical therapy programs for patients with DN will include MET because it is more effective.

Limitations

The current study was limited by differences in patient motivation; some patients feared falling, refused to be transported to different locations during assessment and treatment, and experienced changes in lifestyle and educational levels. [EDITOR COMMENT: OR ". Some patients feared falling or refused to be transported to different locations during assessment and treatment. In addition, patients differed in lifestyle and educational levels."]

Conclusions

MET improved motor NCV and isometric muscle strength in patients with type 2 DN.

Recommendations

We recommend continued follow-up and assessment of long-term effects.

Acknowledgments

We extend deep thanks to the cooperative participants who contributed to this research.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Research Ethics Committee at the Faculty of Physical Therapy, Modern University for Technology, and Information (approval No.: REC/2111/MTI.PT/2204061). Clinical trial registration: NCT05790421.

Informed consent

Informed consent was obtained from all individuals included in this study.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors declare no conflicts of interest.

Funding

This research received no external funding.

References

[1] Feldman EL, Callaghan BC, Pop-Busui R, Zochodne DW, Wright DE, Bennett DL, Bril V, Russell JW, Viswanathan V. Diabetic neuropathy. Nat Rev Dis Primers. 2019;5(1): 41; doi: 10.1038/s41572-019-0092-1.
[2] Iqbal Z, Azmi S, Yadav R, Ferdousi M, Kumar M, Cuthbertson DJ, Lim J, Malik RA, Alam U. Diabetic peripheral neuropathy: epidemiology, diagnosis, and pharmacotherapy. Clin Ther. 2018;40(6):828–49; doi: 10.1016/j.clinthera.2018.04.001.
[3] Hwang S, van Nooten F, Wells T, Ryan A, Crawford B, Evans C, English M. Neuropathic pain: a patient-centered approach to measuring outcomes. Health Expect. 2018; 21(4):774–86; doi: 10.1111/hex.12673.
[4] Kim SS, Won JC, Kwon HS, Kim CH, Lee JH, Park TS, Ko KS, Cha BY. Prevalence and clinical implications of painful diabetic peripheral neuropathy in type 2 diabetes: results from a nationwide hospital-based study of diabetic neuropathy in Korea. Diabetes Res Clin Pract. 2014;103(3):522–9; doi: 10.1016/j.diabres.2013.12.003.
[5] Qureshi MS, Iqbal M, Zahoor S, Ali J, Javed MU. Ambulatory screening of diabetic neuropathy and predictors of its severity in outpatient settings. J Endocrinol Invest. 2017;40:425–30; doi: 10.1007/s40618-016-0581-y.
[6] Callaghan BC, Cheng HT, Stables CL, Smith AL, Feldman EL. Diabetic neuropathy: clinical manifestations and current treatments. Lancet Neurol. 2012;11(6):521–34; doi: 10.1016/S1474-4422(12)70065-0.
[7] Timar B, Timar R, Gață L, Oancea C, Levai C, Lungeanu D. The impact of diabetic neuropathy on balance and on

the risk of falls in patients with type 2 diabetes mellitus: a cross-sectional study. PLoS One. 2016;11(4):e0154654; doi: 10.1371/journal.pone.0154654.
[8] Bondor CI, Veresiu IA, Florea B, Vinik EJ, Vinik AI, Gavan NA. Epidemiology of diabetic foot ulcers and amputations in Romania: results of a cross-sectional quality of life questionnaire based survey. J Diabetes Res. 2016; 2016:5439521; doi: 10.1155/2016/5439521.
[9] Juster-Switlyk K, Smith AG. Updates in diabetic peripheral neuropathy. F1000Res. 2016;5(F1000 Faculty Rev): 738; doi: 10.12688/f1000research.7898.1.
[10] Chaitow L. Muscle Energy Technique. 3rd ed. Edinburgh: Churchill Livingstone Elsevier; 2008: pp. 143–254.
[11] Waldén M, Hägglund M, Magnusson H, Ekstrand J. Anterior cruciate ligament injury in elite football: a prospective three-cohort study. Knee Surg Sports Traumatol Arthrosc. 2011;19(1):11–9 doi: 10.1007/s00167-010-1170-9.
[12] Greenman PE. Principles of Manual Medicine. 19962nd ed. Baltimore: Williams and Wilkins; 1989: pp. 430–9.
[13] Lenehan KL, Fryer G, McLaughlin P. The effect of muscle energy technique on gross trunk range of motion. J Osteopathic Med. 2003;6(1):13–8.
[14] Schleip R. Fascial plasticity – a new neurobiological explanation. Part 2. J Bodyw Mov Ther. 2003;7(2):104–16; doi: 10.1016/S1360-8592(02)00076-1.
[15] Marusteri M, Bacarea V. Comparing groups for statistical differences: how to choose the right statistical test? Biochem Med. 2010;20(1):15–32.
[16] Sarwar N, Gao P, Seshasai SR, Gobin R, Kaptoge S, Di Angelantonio E, Ingelsson E, Lawlor DA, Selvin E, Stampfer M, Stehouwer CDA, Lewington S, Pennells L, Thompson A, Sattar N, White IR, Ray KK, Danesh J. Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. Lancet. 2010;375(9733):2215–22; doi: 10.1016/S0140-6736(10)60484-9.
[17] Ta S. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2014;37:81–90; doi: 10.2337/dc14-S081.
[18] Preston DC, Shapiro BE. Electromyography and Neuromuscular Disorders E-Book. Clinical-Electrophysiologic Correlations. Elsevier Health Sciences; 2012.
[19] McClinton S, Collazo C, Vincent E, Vardaxis V. Impaired foot plantar flexor muscle performance in individuals with plantar heel pain and association with foot orthosis use. J Orthop Sports Phys Ther. 2016;46(8):681–8; doi: 10.2519/jospt.2016.6482.
[20] Chaitow L, Crenshaw K. Muscle Energy Techniques. Elsevier Health Sciences; 2006.
[21] Andreassen CS, Jakobsen J, Ringgaard S, Ejskjaer N, Andersen H. Accelerated atrophy of lower leg and foot muscles – a follow-up study of long-term diabetic polyneuropathy using magnetic resonance imaging (MRI). Diabetologia. 2009;52(6):1182–91; doi: 10.1007/s00125-009-1320-0.
[22] Parasoglou P, Rao S, Slade JM. Declining skeletal muscle function in diabetic peripheral neuropathy. Clin Ther. 2017;39(6):1085–103; doi: 10.1016/j.clinthera.2017.05.001.
[23] Fryer G, Ruszkowski W. The influence of contraction duration in muscle energy technique applied to the atlanto-axial joint. Int J Osteopath Med. 2004;7(2):79–84; doi: 10.1016/S1443-8461(04)80016-9.
[24] Wang J, Wang S, Wu H, Dong S, Zhang B. Muscle energy technique plus Neurac method in stroke patients with hemiplegia complicated by diabetes mellitus and assessment of quality of life. Dis Markers. 2022;2022: 6318721; doi: 10.1155/2022/6318721.
[25] Gad Elhak RKAE, Battesha HHM, Samir SM. Muscle energy technique versus active release technique on motor functions in patients with carpal tunnel syndrome. Int J Ther Rehabil. 2014;28(7):1–11; doi: 10.12968/ijtr.2020.0114.
[26] Sartor CD, Watari R, Pássaro AC, Picon AP, Hasue RH, Sacco ICN. Effects of a combined strengthening, stretching, and functional training program versus usual care on gait biomechanics and foot function for diabetic neuropathy: a randomized controlled trial. BMC Musculoskelet Disord. 2012;13:36; doi: 10.1186/1471-2474-13-36.
[27] El-Refay BH, Ali OI. Efficacy of exercise rehabilitation program in improving gait of diabetic neuropathy patients. Med J Cairo Univ. 2014;82(2):225–32.