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ORIGINAL ARTICLE

Investigating the Role of Backward Walking Therapy in Alleviating Plantar Pressure of Patients With Diabetic Peripheral Neuropathy

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Abstract

Objective: To investigate the effect of combination therapy of backward walking training and alpha-lipoic acid (ALA) treatment on the distribution of plantar pressure in patients with diabetic peripheral neuropathy (DPN).

Design: This study is a double-blinded, randomized controlled trial. The test group was treated with combination therapy of backward walking exercise and ALA (ALA for 2wk, backward walking exercise for 12wk), and the control group only received ALA treatment.

Setting: Clinical and laboratory setting.

Participants: Patients with DPN (N=60) were divided into the test group (n=30) or control group (n=30).

Interventions: Backward walking exercise with ALA treatment for the test group; lipoic acid treatment for the control group.

Main Outcome Measure: Plantar pressure before and after treatment was tested and analyzed with the flatbed plantar pressure measurement system.

Results: After treatment, peak plantar pressure in the forefoot dropped for both the test and control groups; peak plantar pressure for the test group dropped significantly. Peak plantar pressure in the medial foot slightly increased for the test group, suggesting a more even distribution of plantar pressure in the test group after treatment.

Conclusions: The combination therapy of ALA and backward walking proved to be more effective than ALA monotherapy. Backward walking also proved to have an ameliorating effect on balance ability and muscle strength of patients with DPN.

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Diabetic foot ulcers (DFUs) are the most common and serious complication of diabetes mellitus (DM) that account for the leading cause of lower limb amputation.[1] Around 50% of patients with type 2 DM have complications with DFUs, which are worsened with the age of the patient and progression of the disease. Previous investigations[2] have shown that abnormalities of foot pressure and plantar pressure distribution are some of the major causes of the onset of DFUs. Among these studies,[3,4] high plantar pressure is the independent risk factor of DFUs; relevance of plantar pressure predicting DFUs is as high as 70% to 90%. As such, testing on plantar pressure of patients with DM is of pivotal importance to the evaluation of the risk of onset of DFUs.

Alongside research on plantar pressure of forward walking, since the 1980s, research on healthy people and older adults has found that backward walking allows a more even distribution of the plantar pressure and plays a unique role in improving muscle strength of the lower extremities, balance ability, and aerobic capacity.[5-8] Albensi et al[9] observed that body mass to the heel forces of forward walking are larger than that of backward walking. Lower extremity injuries are often caused by repeated, excessive, or inappropriately timed heel forces or a combination of these during locomotion,[10,11] suggesting that backward walking might help in reducing the impact of lateral hindfoot impingement. Zhao et al[12] tested the dynamics of plantar pressure distribution of 48 older adults during forward and backward walking

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while using a high-frequency plantar pressure measurement system. Results showed that backward walking compared with forward walking allows a more even distribution of plantar pressure and improves the balance and coordination abilities of the body and the contractibility of the muscle.

After testing 418 patients with DM and 132 healthy controls, Xiao et al[13] found that diabetic peripheral neuropathy (DPN) is a significant risk factor for increased plantar pressure in patients with DM. Besides controlling the blood glucose level, ameliorating peripheral neural function is an important aspect in the treatment of DPN.[14] A wealth of research has shown that alpha-lipoic acid (ALA) could reduce and prevent free radical damage through antioxidative action and further alleviate the symptoms of DPN and increase nerve conduction velocity.[15-24] A growing body of evidence suggests that oxidative stress resulting from enhanced free radical formation and/or defects in antioxidant defense is implicated in the pathogenesis of diabetic neuropathy. Markers of oxidative stress (eg, superoxide anion, peroxynitrite production) are increased in patients with DM in relation with the severity of polyneuropathy. In experimental diabetic neuropathy, oxygen free radical activity in the sciatic nerve is increased, and treatment with thioctic acid, a potent lipophilic antioxidant, results in prevention or improvement of the diabetes-induced neurovascular and metabolic abnormalities in various organ systems. Pharmacodynamic studies have shown that thioctic acid favorably influences the vascular abnormalities of diabetic polyneuropathy, such as impaired microcirculation, increased indices of oxidative stress, and increased levels of markers for vascular dysfunction (eg, thrombomodulin, albuminuria, nuclear factor-kappaB).[21] In addition, physical exercise (eg, backward walking) is another effective method for improving peripheral neural function. Previous research has suggested that backward walking significantly reduces the impact force on contact because of reduced stride length, foot contact pattern, and lower extremity kinematic pattern.[25] Advantages of backward walking include reduced ground reaction forces at contact, limited range of motion at the knee joint (advantageous during knee injury rehabilitation), augmented stretch of the hamstrings muscle group during the stride, and the potential of proprioceptive/balance control training during activity.[26] Błażkiewicz[27] investigated the muscle force distribution during forward and backward locomotion; results show that good validation by the electromyographic signal was obtained for the m. rectus femoris, m. biceps femoris short head, and m. tibialis posterior during forward and backward walking. However, for the m. iliacus, good validation was only achieved during backward walking. Research by Hoogkamer et al[28] observed pronounced crossed responses in the tibialis anterior: during backward walking, in order to maintain stability and balance, there is markedly higher tibialis anterior reflex activity in the contralateral leg. In addition, in backward walking a substantial reflex suppression was observed in the ipsilateral biceps femoris during the stance-swing transition in some participants, whereas for the medial gastrocnemius the reflex activity was equal to background activity in both legs.[28] Research by Jansen et al[29] showed that some muscles show direction-specific contributions (ie, dorsiflexors). Therefore, the authors propose that backward walking uses extra elements, presumably supraspinal, in addition to a common spinal drive.

In this article we investigate the distribution of peak plantar pressure and dynamic impulse of patients with DM when doing backward walking in order to understand if backward walking could help improve these abnormalities of distribution. Meanwhile, we use ALA treatment as the control method, investigating the role of ALA treatment both alone and with the combination of backward walking in improving peripheral neural function. We aim to provide clinical evidence for developing backward walking therapy among patients with DM and guiding the patients with DM to more effective and suitable methods of exercise. This delays the progression of DM or even reduces or prevents its pathogenesis.

List of abbreviations:

ALA **alpha-lipoic acid**
DFU **diabetic foot ulcer**
DM **diabetes mellitus**
DPN **diabetic peripheral neuropathy**

Methods

Participants

General background of participants

We identified 60 cases of inpatients and outpatients with DPN at the Department of Endocrinology of Beijing Military General Hospital between June 2011 and August 2012. This is a double-blinded, randomized controlled trial. The patients were randomly divided into the test group and control group; each group had 30 cases. The differences in the baseline characteristics between these 2 groups of patients have no statistical significance (table 1). This study was reviewed and approved by the ethics committee of the Beijing Military General Hospital, and all participants signed a formal consent form (fig 1).

Selection criteria

The 60 cases of patients with DPN selected are all in compliance with the standard of the Definition, Diagnosis and Classification of Diabetes Mellitus and its Complications by the World Health Organization[30] in 1999. Because there is currently no definitive standard of diagnosis for DPN, an interim standard that is comprehensive of the available reference materials is formulated as follows: (1) the patient has a clear disease history of DM; (2) the patient has signs of neuropathy at or after the diagnosis of DM; (3) the patient has clinical symptoms and indicators that are descriptive and typical of DPN, including numbness and tingling of extremities, loss of sensation, or abnormal sensation (dysesthesia) to a body part (eg, burning, electric pain); and (4) the patient can be diagnosed as having DPN if at least 2 of the 5 following clinical indicators are shown: abnormal sense of temperature, abnormal nylon monofilament test, numbness or loss of sensation in the foot, vibration perception threshold >25V, and disappearance of Achilles tendon reflexes.

Exclusion criteria

The patient is excluded if they have (1) severe deformity in foot bones, history of severe traumatic injuries in the foot, history of amputation above the metatarsal bones, or abnormality in the foot and ankle joint activities during testing; (2) poor vision that affects walking; (3) severe cardiopulmonary insufficiency that affects