Whirlpool Therapy Improves Nerve Function and Dynamic Standing Balance in Patients with Diabetic Peripheral Neuropathy

Whirlpool Tedavisi Diabetik Periferik Nöropatili Hastalarda Sinir Fonksiyonlarını ve Ayakta Durma Dengesini Arttırır

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ABSTRACT

Objective: Although whirlpool therapy is well documented to improve blood flow, nutrition and oxygen to the tissues, remove metabolic waste, soften skin, nerve conduction and relieve pain in various conditions, it has not been intensively used as a therapeutic modality for Diabetic peripheral neuropathy (DPN) clinical features. Therefore, this study was planned to investigate the effect of whirlpool application on motor peroneal nerve function and dynamic standing balance in patients with DPN.

Methods: Forty three patients with DPN were randomly identified and allocated into either experimental or control group. The control group feet received no management program. In contrary, the experimental group feet received a short and long term management programs of whirlpool therapy. The short term management program included one session of 15 minutes of whirlpool therapy whereas the long term management program included, 15 minutes of whirlpool therapy three sessions a week for four weeks. M-wave of extensor digitorum brevies (MWEDBM) and dynamic standing balance were recorded to assess the efficacy of the used management programs.

Results: This study showed that both the MWEDBM and sensory/motor dynamic standing balance of the control group were significantly unchanged throughout the testing conditions ($p<0.98$; $p<0.20$); ($P<0.22$-0.95). In contrary the MWEDBM and sensory dynamic standing balance of the experimental group were significantly improved after short and long term management programs ($p<0.001$).

Conclusion: Whirlpool management program can be used as a non pharmacological agent, to improve nerve function and dynamic standing balance in patients with DPN. *(J PMR Sci 2010;13:58-64)*

Keywords: Whirlpool, diabetic peripheral neuropathy, balance, M-wave

ÖZET

Amaç: Whirlpool tedavisinin bir çok durumda kan akımını arttırdığı, dokuların beslenmesi ve oksijenasyonunu arttırdığı, metabolik artıkları uzaklaştırdığı, cildi yumuşattığı, sinir iletimini arttırdığı ve ağrıyı azalttığı ortaya konmuştur, ancak diabetik periferik nöropatide klinik bulgular için bir terapötik modalite olarak yoğun kullanılmamaktadır. Bu nedenle bu çalışma diabetik periferik nöropatili hastalarda whirlpool tedavisinin peroneal sinir motor fonksiyonlarına ve dinamik ayakta durma dengesine etkileri araştırılmak üzere planlandı.

Yöntemler: Diabetik nöropatili 43 hasta rastgele seçilerek çalışma ya da kontrol grubu olarak ayrıldı. Kontrol grubunda ayaklara herhangi bir uygulama yapılmadı. Buna karşılık çalışma grubunda ayaklara kısa ve uzun dönem whirlpool tedavisi programı uygulandı. Kısa dönem programı tek seans 15 dakikalık

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Received/Geliş Tarihi: *06.11.2009*
Accepted/Kabul Tarihi: *22.03.2010*

whirlpool tedavisinden oluşurken, uzun dönem programı 4 hafta süre ile haftada 3 kez 15'er dakikalık whirlpool tedavisinden oluşuyordu. Programların etkinliğini değerlendirmede dinamik ayakta durma dengesi ve ekstansör digitorum brevis (EDB) kasına ait M yanıtı kaydedildi.

Bulgular: Bu çalışma kontrol grubunda çalışma süresince duysal/motor dinamik ayakta durma dengesinin ve EDB M yanıtlarının değişmediğini göstermiştir (p<0,98; p<0,20); (p<0,22-0,95). Buna karşılık çalışma grubunda kısa ve uzun dönem whirlpool programı uygulaması ile dinamik ayakta durma dengesinin ve EDB M yanıtlarının anlamlı düzelmiştir.

Sonuç: Whirlpool tedavisi diabetik periferik nöropatili hastalarda sinir fonksiyonlarını ve dinamik ayakta durma dengesinin arttırmak için nonfarmakolojik bir yöntem olarak kullanılabilir. *(FTR Bil Der 2010;13:58-64)*

Anahtar kelimeler: Whirlpool, diabetik peripherik nöropati, denge, M-yanıtı

Introduction

Diabetic peripheral neuropathy (DPN) represents 60% of type 2 diabetes mellitus, is usually affects the lower extremity more than the upper extremity and decreases the patient's quality of life(1). It has many clinical features including sensory and motor dysfunctions, feet skin hardness and microcirculation defect (2,3).

The sensory neuropathy presented as tingling, burning and prickling sensations, decreased feet sensation and proprioception (4,5,6). It interrupts conduction of somatosensory nerve pathways (7) Somatosensory function is thought to be the most important factor to control standing postural stability, contributing at least 60-75% of the control of stance posture when a subject stands on a firm surface (7).

The motor neuropathy results in diminished of deep tendon reflexes, 4,8 weakened intrinsic foot muscles and ankle instability. It associates with slow common and deep peroneal nerve conduction velocity and reduced or absent compound muscle action potential (9).

The feet skin hardness is believed to reduce perception of the cutaneous sensory inputs impairing standing balance, results from abnormal planter pressure in neuropathic feet (10).

Microcirculation defect e.g. vessel permeability, ischemia is most likely due to impairment of axon reflex-related vasodilatation (3,11).

Alteration of blood vessel permeability may cause endoneural edema, which compromise endoneural blood flow (12) Ischemia is reported to cause nerve irritation/damage.

These clinical features are reported to cause physical disability in particularly postural instability during standing and walking (13), increase the risk of falling and gait impairment (14,15) They have been managed conservatively using diet, transcutaneous electrical nerve stimulation, iontopheresis, heat, vacuum compression and dynamic exercises. The efficacy of these therapeutic modalities has been mainly determined by electrophysiological and dynamic standing balance measures (16).

It is surprising that whirlpool bath has not been intensively used as a therapeutic modality for DPN clinical features. Although whirlpool therapy is well documented to improve blood flow, nutrition and oxygen to the tissues, remove metabolic waste and relieve pain in various medical conditions (17,18,19) It also reported to soften skin hardness which in turn improve foot flexibility and sensory perception (20).

Therefore, this study was planned to investigate the effect of short and long terms application of whirlpool bath on motor peroneal nerve function and dynamic standing balance in patients with DPN.

Patients and Methods

Forty three patients with DPN, 17 males and 26 females were participated in this study. They were randomly identified from diabetic center at King Abdul Aziz University Hospital (KAUH), Riyadh, Saudi Arabia, and were allocated into either experimental or control group. The experimental group included 26 patients, (11 males and 15 females) with mean age 47.05±4.37 years. The control group included 17 patients, (6 males and 11 females) with mean age 47.80±5.66 years. They had type 2 diabetes mellitus, with mean fasting capillary blood glucose concentration value 126±5 mg/dl. Clinically, they all complained of very light intermittent feet pain, tingling, burning and prickling sensation. The mean duration of DM since diagnosis was 4±1 years. Patients with constant feet burning pain, proximal diabetic neuropathy, autonomic neuropathy, focal neuropathy, foot ulcers, charcot foot, anemia, cardiac diseases, disc herniation, lumbosacral degeneration, sever vision disturbance, sever hypoglycemic attack, and hypotension were excluded.

Feet of each patient in the experimental group received two whirlpool management programs, short and long term programs. The short-term management program included one single session of 15 minutes of 39 degree centigrade of warm water agitating in whirlpool tank. The long-term management program included three sessions a week of 15 minutes of 39 degree centigrade of warm water agitating in whirlpool tank for four weeks, for a total of 12 sessions. This program was started one day after the completion of the short term management program. During the management session, the temperature of the agitating water was frequently checked with regular fluid thermometer. The temperature of the whirlpool water was maintained by adding a hot water.

The feet during both programs were placed and relaxed on the floor of the whirlpool tank, while patient sat in a comfortable chair.

Experimental Procedures

The procedure of this study was ethically revised and approved by the Rehabilitation Sciences Department and the Deanship of graduate studies, at King Saud University.

Then, a brief oral introduction for the study objectives, experimental procedure and management protocol was presented for each patient. After ward, a written consent form was obtained.

M-wave of extensor digitorum brevies (MWEDB) and dynamic standing balance before (condition 1) and immediately at the end of the short term management program (condition 2) were measured. These out-come measures were again recorded at the end of two weeks of the long term management program (condition 3) and at the end of the long term management program (condition 4).

The control group received no management program. Their MWEDB and dynamic standing balance were assessed twice in the first visit within half an hour interval. The first assessment in this visit was called condition 1, and the second assessment was called condition 2. The same assessments procedures were again recorded immediately after two weeks from the first visit, was called condition 3.

The MWEDB muscle was recorded using EMG Medtronic machine, with stimulation-recording parameters of 2 mv/D sensitivity, sweep of 5 ms/D, band width of 20-10000 HZ, 0.1 ms stimulus duration and 1 HZ stimulus frequency. It was measured while the patient relaxed supine on comfortable bed with the head turned to the right side, arms a side and small pillow placed under the legs and head.

Then the skin above the extensor digitorum brevies muscle and peroneal nerve at ankle joint was gently abraded with soft sand-papered and cleaned with alcohol swab to reduce skin resistance. Then, a surface bar recording electrode with coupling conductive gel was positioned on the belly of the extensor digitorum brevies muscle. It was fixed with adhesive tape to insure maximum conduction and stability. Active recording electrode was proximal to reference electrode. A surface bar stimulating electrode with coupling conductive gel was positioned on the anterior surface of the ankle in the mid position between medial and lateral malleoli. The cathode stimulating electrode was distally facing the active recording electrode. It was fixed with adhesive tape. A ground electrode was a round metal piece 5 mm in diameter with conductive gel, was adjusted and positioned between the stimulating and recording electrodes.

The intensity of the stimulator was then increased gradually until maximum M-wave was obtained. Two minutes of practice run of maximum M-wave recording was carried out, followed by two minutes rest. Then three readings of peak-to-peak maximum M-wave were recorded and the averaged was taken for statistical analysis. After that, the stimulating - recording electrodes were removed. The positions of the electrodes were marked with red color to ensure the accuracy of the electrodes placement in the next assessment in the same visits. Then the patient's feet were immersed inside the whirlpool tank.

The belly of the extensor degitorum brevies muscle was identified by active voluntary dorsiflexion of the patient's ankle against maximum resistance. It arose from the distal part of superior and lateral surfaces of the calcaneus, lateral talocalcaneal ligament, and apex of inferior extensor retinaculum, inserted into dorsal surface of the base of proximal phalanx of great toe, other three tendons join lateral sides of tendons of extensor digitorum longus to second, third, and fourth digits.

Dynamic standing balance was measured using computerized dynamic posturography (Equi test, Neurocom Int Inc). It consisted of (1) a support surface, provided with pressure-sensitive strain gauges located in each quadrant that can translate horizontally forward or backward and rotate about an axis colinear with ankle joint. It recorded the vertical forces between legs and ground as well as horizontal shear forces. (2) A movable visual surround, which enclosed the patients visual surrounding and rotated about an axis colinear with ankle joint. (3) and a computer that analyzed data. The dynamic standing balance assessment in this study included, Sensory Organization Test (SOT) and Motor Control Test (MCT). The patient starting position of both tests was standing upright with weight equally distributed on both legs on the support surface enclosed by a visual surround.

Sensory Organization Test

The SOT assessed the ability of patients to use visual, vestibular or somatosensory information to maintain upright stance under different sensory conditions. SOT consisted of six separate trials lasting 20 sec each and repeated three times to get stable readings. The average of these three readings was recorded for statistical analysis.

The SOT Trials Procedure

SOT1 eyes were opened (EO), Romberg's test was done with the patient standing with eyes opened and the visual surround and the support surface were stable. SOT2 was similar to the SOT1 except that the eyes were closed (EC). SOT3 visual sway (SV), with eyes were opened, the visual surround was moved in response to the body sway. SOT4 eyes were opened support surface swayed (EOSS), support surface was swayed and the visual surround was stabled. SOT5 eyes were closed, support surface was swayed (ECSS). SOT6 (SVSS) the support surface and the visual surround were swayed with opened eyes.

SOT scores were based on the assumption that a normal individual can exhibit anterior to posterior sway over a total range of 12.5 degrees without losing balance. The equilibrium scores were varying from 0, which represented maximum sway or patient's fall, to 100, which represented no body sway or perfect stability.

Before testing, the patient was informed about the feeling of each trial to familiarize him/her with the testing procedure. Then, one practice run of trials was performed followed by actual recording.

Motor Control Test (MCT)

The MCT studies automatic postural responses to rapid, involuntary movement of support surface. It consisted of small, medium, and large forward and backward perturbation trials for the right and left legs to stimulate falling. Each perturbation trial was repeated three times and the average was taken for statistical analysis. From the perturbations the force response of each leg was evaluated to yield force symmetry scores between right and left legs. Translation intensities were normalized to hight of the subject to obtain three sway angles: small translation=0.7 degrees of sway, medium translation=1.8 degrees of sway, large translation=3.2 degrees of sway. Result was expressed as latency. The latency represented the time interval from the onset of support surface perturbation to the point at which a subject began to actively resist the induced sway.

Data Analysis

The data of this study were statistically analyzed using repeated measure ANOVA, followed by post hoc LSD test with p<0.05. Independent t-test with p<0.05 was also performed for comparison between control and experimental groups data recorded in the first visit.

Results

Six patients out of 26 of the experimental group were discontinued their long term management program due to difficulty in transportation and traveling.

M-wave of Extensor Digitorum Brevis Muscle (MWEDBM).

Both the latency and amplitude of the MWEDBM of the control group were significantly unchanged throughout the testing conditions with p<0.98; p<0.20 respectively (Table 1).

In contrary, the latency of the experimental group was significantly improved (p<0.001) after the management programs. It started with (4.28±0.98 msec) and improved to (3.83±0.85 msec) immediately at the end of the short term management program, (3.70±0.81 msec) immediately after two weeks of long term management program and (3.52±0.75 msec) at the end of the long term management program (Table 1). The improvement in latencies throughout the management programs were statistically significant with p<0.001.

The amplitude of experimental group was significantly recovered (p<0.001) after the management programs (Table 1). It started with (3.83±2.07 mv) and increased to (4.17±2.19 mv) at the end of the short term management program, (4.60±2.24 mv) immediately after two weeks of long term management program and (5.05±1.98 mv) at the end of the long term management program. The improvement in the amplitudes throughout the management programs were statistical analysis with p<0.001- 0.04.

The experimental and control groups had statistically similar latencies (p<0.51) and amplitudes (p<0.89) of the MWEDBM recorded in the first visit. The experimental group had latency of 4.28±0.98 msec and amplitude of 3.83±2.07 mv compared with 4.33±1.37 msec and 3.69±2.27 mv for the control group.

Sensory Organization Test (SOTs)

SOTs trials recorded from the control group throughout the testing conditions were not significantly different with p <0.22- 0.63 (Table 2). In contrary, SOTs trials recorded from the experimental group were significantly improved immediately at the end of the short term management program (p<0.001). This improvement maintained during and at the end of the long term management program with p<0.001 (Table 3).

The SOTs recorded from both groups during the first visit were not statistically significant different p<0.06- 0.96 (Table 4).

Motor Control Test (MCT)

The average latencies in MCT for backward and forward perturbations of both legs of the control group were significantly unchanged throughout the testing conditions with p<0.25- 0.95 (Table 5). The average latencies in MCT for backward and forward perturbations of both legs of the experimental group were also significantly unchanged throughout the management programs with p<0.2-0.7 (Table 6).

Both groups had a non significant difference in latency of MCT for backward and forward perturbations with p<0.12-0.96 (Table 7).

Discussion

This study showed that management of diabetic feet with agitating warm water in whirlpool significantly improved the motor peroneal nerve function and dynamic standing balance in patients with diabetic peripheral neuropathy. These improvements could be due to the fact that the warm water of whirlpool vasodilated blood vessels in feet and/or improved local sensation of patients with DPN. Sussman (1990) (21) demonstrated that whirlpool application increases vasodilata-

Table 1: Mean±SD of latency and amplitude of MWEDBM in the control and experimental groups

Group	Testing	Condition 1	Condition 2	Condition 3	Condition 4	P-value
Control	Latency (msec)	4.33±1.37	4.31±1.34	4.31±1.30	_ _	0.98
	Amplitude (mv)	3.69±2.26	3.69±2.26	3.96±2.15	_ _	0.20
Experimental	Latency (msec)	4.28±0.98	3.83±0.85	3.70±0.81	3.52±0.75	0.001
	Amplitud e (mv)	3.83±2.07	4.17±2.19	4.60±2.24	5.05±1.98	0.001

tion of the superficial vessels, increasing oxygenation and nutrition around superficial tissues and nerves. Moreover, comfortable heating of feet tissue is reported to improve local sensations and superficial blood flow in patients with DPN (22,23). These improvements are reported to be related to production of nitric oxide (23,24).

Vasodilation as a result of nitric oxide production in patients with DPN has been reported to improve nerve function by increasing available oxygen and glucose (24) Such changes allow ATP-ase production to establish normal sodium and potassium ions concentrations across the nerve cell membrane and normal depolarization of action potential is therefore produced (25). The continuous improvement in motor peroneal nerve function after long term application of whirlpool in our study is a sign to support the assumption that Na+/K+ ions concentration across the nerve cell membrane of patients with DPN is moving toward a healthy level (26,27). It has been reported that slowing of conduction velocity (CV) and reduction of compound muscle action potential amplitude correlated with disturbance of Na+/K+ ions pump function in patients with DPN.28 Improvement in latency and amplitude of MWEDBM after application of whirlpool in the present study indicated possible enhancement in Na+/K+ ions pump permeability along nerve cell membrane in patients with DPN. It also could suggest that the mechanical vibrating and agitating movement of warm water of whirlpool bath reduce swelling and accumulation of water in the schwann cells of the peroneal nerve.

Another possible explanation for the improvement in motor nerve function and dynamic standing balance is the positive effect of whirlpool bath on diabetic feet skin hardness. Whirlpool bath has been reported to soften skin hardness in the foot, remove necrotic tissues, improve tissue oxygenation and increase skin extensibility (20,29,30). It has been reported that skin softening increases cutaneous sensation awareness (31-33). Therefore, whirlpool application in the present study may improve sole of the feet skin sensation as a result of skin softening and removal of superficial rough tissues. This improvement in skin condition may encourage somatosensory receptors to receive more and accurate information from the outer environment. The continuous enhancement in SOTs of the experimental group in our study after whirlpool application agreed with the previous finding.

Moreover, poor oxygenation in the smallest blood vessels in the distal parts of limbs disrupts somatosensory function (7) This could explain the impaired dynamic standing balance in the experimental group before whirlpool management program. Therefore, oxygenation in the smallest blood vessels in the distal parts of the limbs of patients with DPN should be considered as one of the factors affect dynamic standing balance. The reported increase in tissues oxygenation after whirlpool application (Sussman 1990) 21 and improvement of SOTs in our study support this notion.

The significant improvement in SOTs and motor nerve function after whirlpool application reached the previously reported healthy levels (13,27,28,34,35). This could imply that patient with DPN has a good potential to recover if managed at early stage of the problem. It seems that patients at early stage of DPN have mainly peripheral nerves irritation and blockage. Once the causes of irritation and blockage are removed nerves function recover towards normal limit (36). This is most likely true because the improvement in nerve function and SOTs of the patients in our study after whirlpool management reached the healthy levels. Recovery of degenerated / demyelinated nerves is not expected to occur after 15 min of whirlpool application.

Although the whirlpool management aimed somatosensory function in feet but not vision or vestibular functions, all SOTs of experimental group significantly improved. This could indicate that the somatosensory function in feet is the most important factor to maintain dynamic standing balance in this group of patients. It may also suggest that the dynamic posturography Equi test reflects the patient's difficulty in using somatosensory information, rather than impairment in vestibular or visual systems. Patients with vision and/or vestibular deficit are not expected to have normal SOTs

Table 2: Mean±SD of Sensory Organization Test of the control group

Trials	Condition 1	Condition 2	Condition 3	P-value
SOT1 (%)	92.47±2.53	92.53±2.29	93.41±2.53	0.22
SOT2 (%)	92.47±2.55	92.94±2.97	93.00±3.64	0.56
SOT3 (%)	93.24±3.51	92.71±3.33	92.94±3.34	0.56
SOT4 (%)	75.41±11.76	76.65±9.99	74.29±10.75	0.49
SOT5 (%)	64.29±19.77	64.76±17.10	67.71±19.28	0.63
SOT6 (%)	67.59±10.39	66.71±11.57	70.18±16.29	0.28

Table 3: Mean±SD of Sensory Organization Test of the experimental group

Trials	Condition 1	Condition 2	Condition 3	Condition 4	P-value
SOT1 (%)	90.75±2.84	94.00±2.10	94.60±1.23	94.20±1.58	0.001
SOT2 (%)	89.00±4.77	93.75±1.86	93.70±1.84	93.45±1.54	0.001
SOT3 (%)	85.60±8.97	91.00±6.87	92.65±4.55	92.15±5.30	0.001
SOT4 (%)	60.85±14.24	74.55±12.58	75.75±11.87	78.60±11.36	0.001
SOT5 (5)	55.60±11.38	68.30±11.82	68.65±7.78	70.65±8.97	0.001
SOT6 (%)	54.60±11.82	65.60±14.28	65.55±12.97	67.60±12.08	0.001

(7,11,13). Nardo et al., (1999) 13 believed that the somatosensory information is the important factor to effect dynamic standing balance rather than a specific lesion of vestibular and/or visual modalities.

In contrary, the latencies of MCT of the experimental group in this study were obviously prolonged and did not significantly change after the application of whirlpool management programs. Prolonged latencies were also reported in healthy elderly subjects and patients with DPN (34,38). In fact, they reported worse MCT latencies in patients with diabetic neuropathy than in healthy subjects (20,37,38,42,43). Interestingly, the prolonged latencies in our study were far less than previously reported. Perhaps, relatively young and the short duration of DPN of our experimental group are the reasons for such difference.

Table 4: Comparison between control and experimental groups in Sensory Organization Test

Trials	Control group Condition 1	Experimental group Condition 1	p-value
SOT1 (%)	92.47±2.53	90.75±2.84	0.96
SOT2 (%)	92.47±2.55	89.00±4.77	0.06
SOT3 (%)	93.24±3.51	85.60±8.97	0.16
SOT4 (%)	75.41±11.76	60.85±14.24	0.83
SOT5 (%)	64.29±19.77	55.60±11.38	0.90
SOT6 (%)	67.59±10.39	54.60±11.82	0.52

Table 5: Mean±SD of the average latencies of both legs in Motor Control Test of the control group

Trials	Condition 1	Condition 2	Condition 3	P-value
Backward (msec)				
Small	137.1±14.03	137.4±9.70	136.8±14.57	0.95
Medium	131.5±19.90	128.97±18.60	130.9±18.97	0.85
Large	131.5±13.55	134.1±15.83	135.3±16.72	0.40
Forward (msec)				
Small	141.8±15.30	144.4±17.04	147.1±16.59	0.25
Medium	137.9±20.77	142.6±18 .29	142.9±22.29	0.31
Large	133.8±15.96	134.1±15.54	139.1±21.01	0.26

The prolongation in the latencies of MCT was reported to be depend on the NCV and the time the muscles require to exert a force around the ankles to produce movement (34,38).

Although the motor peroneal nerve function was recoverd after whirlpool application, the latencies of MCT did not improve. This might be attributed to the fact that the changes in peripheral nerve fibers of the experimental group were more obvious and faster than that occur in muscle fibers. As the distal muscles in patients with DPN take longer time to recover due to the reported weakness (12,39,44) Muscle weakness in distal lower limb and feet is well documented to associate with DPN patients (5,6,40,41). It seems that recovery in motor nerve function without strengthening exercise for ankle muscles is not enough to enhance latency of MCT in patients with DPN (42) So our study suggested that active ankle exercises during application of whirlpool should be carried out to provide stability during MCT.

The significant stability of peroneal nerve latency, amplitude of MWEDBM and both SOTs and MCT of dynamic standing balance recorded from the control group after two weeks could imply that the DPN has a slowly progressive pathology to impair peripheral nerves and to disturb dynamic standing balance. Asimilar observation was previously reported by John and Williams (1991) (43). Therefore, patients with DPN should be encouraged to control the blood sugar level to delay the further physical complication of diabetes.

Motor nerve function and dynamic standing balance in this study were significantly matched in both groups in the first

Table 7: Mean±SD of the average latencies of both legs in Motor Control Test of the control group

Testing	Control group condition 1	Experimental group condition 1	P-value
Small back	137.06±14.04	146.75±11.39	0.12
Medium back	131.47±19.90	146.75±14.17	0.45
Large back	131.47±13.47	143.75±13.27	0.54
Small forward	141.76±15.30	145.80±11.95	0.19
Medium forward	137.94±20.77	143.5±16.79	0.73
Large forward	133.82±15.96	141.0±14.56	0.96

Table 6: Mean±SD of the average latencies of both legs in motor control test of the experimental group

Testing	Condition 1	Condition 2	Condition 3	Condition 4	P-value
Backward (msec)					
Small	146.8 ± 11.38	143.8 ± 12.65	149.3 ± 14.71	148.8 ± 14.22	0.4
Medium	142.8 ± 10.57	142.5 ± 10.94	143.25± 12.80	146.25 ± 10.37	0.4
Large	144.0 ± 13.04	144.3 ±18.65	140.5 ± 13.26	143.5 ± 11.01	0.7
Forward (msec)					
Small	145.8 ± 11.95	145.0 ± 13.08	146.0 ± 9.59	151.3 ± 9.90	0.4
Medium	143.5 ± 16.78	145.8 ± 15.15	148.8 ± 16.61	149.8 ± 16.09	0.2
Large	141.0 ± 14.56	142.0 ± 14.72	144.8 ± 15.08	145.3 ± 15.34	0.2

testing condition, indicating possible similar pathological changes. The significant improvement in the latency of motor peroneal nerve, amplitude of MWEDBM and SOTs of the experimental group but not control group could confirm that the management program of 15 min of whirlpool application had a positive effect in controlling the early stage complications of diabetic peripheral neuropathy.

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