Neuromuscular Electrical Stimulation And Electrophysiology Of Peripheral Nervous System In Type II Diabetic Patients

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Abstract:

Aim:

The aim of the study is to examine feasibility and effectiveness of short term neuromuscular electrical stimulation (NMES) in both the upper limb, to increases blood flow to limb and therefore the nerves themselves or for electrical current to be having a direct effect on the peripheral nervous system itself and can improve neuropathic symptoms, nerve function and conduction velocity of type 2 diabetic Mellitus Patients..

Methods:

Twenty four patients with T2BM participated in a randomized controlled cross over study ,in which10 week long NEMS intervention were performed on both the upper limbs .The NMES training protocol consisted of 30 minutes session 5 days per week for 10 week. The relative changes in nerve conduction velocities, amplitudes, latencies of sensory and motor component of median nerve, changes in blood glucose and cognitions related blood parameters were evaluated.

Result:

Electrophysiological variables were changed significantly. Distal muscle motor latency(ms) decreased significantly (p= 0.0011), motor conduction velocity(m/s) increased significantly( p=.00011) While the onest latency of left median sensory nerve is comparable between baseline and in after NMES treatment.

Conclusion :

This study showed that 10 weeks long NMES training program could induce greater change in electrophysiological parameters of peripheral nervous system either by increasing
blood flow to the limb and the electrical current to the nerves themselves be having a direct effect on the electrophysiology of nervous system.

INTRODUCTION

Diabetic Mellitus is a world-wide epidemic associated with high morbidity and mortality. Diabetes affects almost all organs of the body therefore it might affect the nervous system also. In the initial stages peripheral nervous system may be affected, however the complication is progressive and may affect the higher enters in the brain too. They all seem to be related to blood sugar level too high for too long time.

Some people have nerve damage with symptoms other have no symptoms(1). Although diabetic neuropathy manifests clinically much later in course of the disease, yet its physiological evidence can be obtained much earlier with the help of electrophysiological tests(2). Electrophysiological investigations like sensory and motor nerve conduction studies are very sensitive method in determining peripheral and central neuropathy.

Nerve conduction studies shows whether the motor nerve transmit electrical impulses to the muscles or sensory nerves up to the brain at a normal speeds (conduction velocity) allow the brain to respond to pain, touch, temperature and vibration.

The first step in management of T2DM patients with diabetic neuropathy should aim for stable glyceamic control, and maintain adequate blood flow. Exercise is fundamental in the prevention and treatment of type 2 Diabetes(3). However many individuals face barrier to exercise. Neuromuscular electrical stimulation is an alternative conventional exercise, to that may prove beneficial in the treatment of T2D. Neuro Muscular Electrical Stimulation (NMES) is the application of mild and comfortable electrical stimulus to the Peripheral nerves using surface electrodes on the motor points of nerves provoking the muscle contraction. Therefore the objective of this study was to investigate whether 10 weeks of training with our NMES stimulation can have a beneficial effect on nerve conduction parameters, heart rate, blood pressure, body composition of the individuals with T2D. Justification to the utilization of NMES is, the sedentary T2DM patients who face barrier to do exercise, NMES is an alternate method of exercise increasing blood flow to the limb and the electric current to the nerve themselves having direct effect on the electrophysiology of nervous system. The NMES has been utilized in the treatment of neurological and other muscular disorders including diabetic neuropathy. Advantages of this treatment is, it is non invasive, non pharmacological, non toxic, non addictive, safe and easy to administer(4). Therefore it is highly desirable to incorporate with the diabetic care routine.

Materials and Methods:
24 patient from both sexes suffering from peripheral neuropathy of diabetic origin for about five years were selected from established cases of T2DM Patients who belongs to the age of 30 to 50 years ,attending the Medicine OP of Kanyakumari Govt. Medical college Hospital Asaripallam.

**Inclusion criteria:**

The patients participated in the study had type 2 diabetes Mellitus and suffering from peripheral neuropathy with or without sensory manifestation. The muscle strength of upper limbs was not less than grade five according to manual muscle testing.

**Exclusion criteria:**

The patients excluded from this study had life threatening disease such as renal failure, myocardial infarction, malignancy or any other serious illness. Patients suffering from other possible causes of neuropathy or neuromuscular diseases for example, hypothyroidism, alcoholism, liver diseases, uses of drugs known to cause neuropathy or myopathy.

**Instruments For Evaluation:**

The Electro physiological test was done using Neuro stim 8 channeled polyrite. The patients were instructed about the procedure. A complete medical examination and detailed neurological examination were carried out for every patients such as examination of Sensory System, Motor System of upper limb, Height, Weight, Basal Pulse, Blood Pressure, Blood Sugar Level, HbA1c, Lipid Profile were evaluated.

**Polyrite:**

The Neurostim 8 channeled polyrite was utilized to study the median motor nerve conduction studies and median sensory nerve conduction studies before and after NMES treatment. The device consist of

- Stimulating unit to which the stimulating electrodes was connected.
- Amplifies to which the recording electrode and the ground electrode were connected.
- Electrodes which consist of stimulating electrodes, ground electrode, two surface recording electrodes in which one is active and other is reference)

**Procedure for Evaluation:**

**Median motor conduction study:**

The subject was made to sit in a wooden chair with arm rest. The recording electrode was placed close to the abductor pollicies muscle and the reference electrode was placed 3 cm distal
to the first metacarpophalangeal joints. Stimulation was given at the wrist (3 cm proximal to the distal crease) and the elbow (near the volar crease)\(^5\).

The distal latency nerve conduction velocity and compound action potential was recorded.

**Median sensory Nerve conduction study:**

The subject was made to sit in a wooden chair. The recording electrode was placed 3 cm proximal to the distal wrist crease and reference electrode was placed at a distance of 3 cm proximally. Stimulation was given in second digit at the first interphalangeal joint and 3 cm distal to it by ring electrode\(^7\). The latency, base to peak amplitude, conduction velocity was recorded.

**For treatment:**

All participants received an accumulated 30 minutes of Neuromuscular Electrical Stimulation at the motor point of median nerve of both the upper limb. The motor excitability allows the motor unit (consisting motor neuron and the muscle innervated by it) to depolarize and to repolarise in turn the muscle contracts and relax.

**Procedure:**

Neuromuscular Electrical stimulation was applied using mini muscle stimulator model DS7A.

The patients were seated comfortably on a chair with standard back support.

The upper limb was strapped to a custom designed hand force plate transducer to determine the velocity of contraction of elbow and the stimulus was given at the elbow portion of the median nerve for peripheral excitability. The NMES stimulator will deliver a set of electrical impulse of 25Hz, 800ms on / 800ms off. The time that the stimulation is on and off, that is during the on time 800 ms the NMES stimulator will deliver a sequence of electrical impulse. The off time of 800ms is rest phase to prevent the muscle becoming over fatigued\(^6\).

**RESULT:**

Distal muscle motor latency (ms) decreased significantly\((P = 0.0011)\) from 3.75± 0.83 to 3.06± 0.31, CMAP amplitude(mv) significantly increased 10.49 ± 3.52 to 11.43± 3.56, motor conduction velocity(m/s) increased \(P=0.0001\) 53.05± 5.91 to 62.68± 5.68, SNAP amplitude mv increased from 13.72± 7.58 to 16.14 ± 5.22, sensory nerve conduction velocity ms increased from 50.62± 6.17 to 56.96± 45.

Table 1: Clinical data of body composition, Blood pressure, resting heart rate of T2DM Patients at baseline and follow-up.

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### Table 2: The Median Nerve conduction parameters of the T2DM Before and after NMES intervention.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Baseline values</th>
<th>After NMES intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distal motor Latency(ms)</td>
<td>3.75 ± 0.83</td>
<td>3.06 ± 0.31*</td>
</tr>
<tr>
<td>CMAP Amplitude(mv)</td>
<td>10.49 ± 3.56</td>
<td>12.13 ± 3.52</td>
</tr>
<tr>
<td>Motor conduction Velocity(m/s)</td>
<td>53.05 ± 5.58</td>
<td>62.68 ± 5.68*</td>
</tr>
<tr>
<td>SNAP Amplitude(mv)</td>
<td>13.72 ± 7.58</td>
<td>16.14 ± 5.22</td>
</tr>
<tr>
<td>Sensory Nerve Latency(ms)</td>
<td>3.7 ± 0.31</td>
<td>3.31 ± 0.13</td>
</tr>
<tr>
<td>Sensory Nerve Conduction Velocity(m/s)</td>
<td>50.62 ± 6.17</td>
<td>56.96 ± 4.5</td>
</tr>
</tbody>
</table>

CMAP-Compound muscle action potential, SNAP-Sensory nerve action potential.

### Discussion:

This study showed that a 10 week NMES exercise programme improved the body composition, glyceamic control, significant reduction in fasting glucose, improvement in the nerve conduction parameters were noted in T2DM participants. Lowering fasting plasma glucose levels is strongly associated with reductions in the risk of complications. However, the change in fasting plasma glucose levels after the NMES intervention are modest, fasting plasma glucose levels correlate poorly with HbA1c.
The current goal of our work is changes in nerve conduction studies, after 10 week NMES intervention, there is a significant increase in nerve conduction velocities motor nerves and the latency of motor nerve has reduced. While the conduction velocity of sensory nerve also increased but not significantly.

Exercise is a vital component in the management and prevention of T2DM, but many individuals with T2DM patients face barrier to exercise to conventional exercise. However prior to this study, there has been a lack of evidence showing the beneficial effects of prolonged NMES intervention on electrophysiology of peripheral nervous system.

Electrophysiological tests support the measurement of speed of both sensory and motor conductions, the amplitude of the propagating neural signal, the density and synchrony of muscle fibres activated by maximal nerve stimulation and the integrity of neural transmission(7).

Therefore Nerve electrophysiological procedures have emerged as an important method of tracing of onset and progression of Diabetic peripheral neuropathy (8). According Kumar and co authors (9) Electrical stimulation for painful neuropathy, there was a significant improvement in neuropathic symptoms. In the studies of Bosi and coauthors reported that there is improvement in the vibration sensation and other sensations after the electrical stimulation (10). From the above studies it is clear that the electrical stimulation improved the symptoms of neuropathy. This study was similar to chih- Chung et al, The neuromodulation of motor excitability has been shown to improve functional movement in people with central nervous system damage (11).

Changes in electrophysiology of the sensory nerve is the most important factors for the neuropathic symptoms, ulceration, infection and amputations (12), and there are no effective treatments for such long fibre neuropathy. In an animal experiment done by Chia-Hong Kao, the cutaneous blood flow in the ipsilateral hind paw of diabetic rats were dramatically increased as elevating electrical stimulation.

Application of NMES is considered to be an better treatment option for large and small fibre neuropathy. This device sends tiny electrical signals to the motor nerves and muscles. As these signals are exactly like the normal nerve signals but much larger and is not dangerous or harmful, these are able to wake up sleeping nerves and strengthens muscles by increasing muscle tone and blood circulation. It opens up the nerve paths, which returns these paths for passing normal signals. Thus NMES helps in improvement of neuropathy by stimulating the muscles to contract and relax, there by increasing blood velocity and volume, increasing collateral circulation and stimulating vasogenesis, stimulating all the afferent and efferent nerves with signals larger than normal to re establish the pathway for subsequent normal signal to follow, draws axon and dendrite of nerve endings closer together to facilitate proper nerve transmission, builds residual pain relief each time the system is used, causes the brain to release endorphins that reduce global pain and anxiety, increases muscle strength for safe pain free walking,
promotes better mobility and balance during the course of treatment. Reduces edema as muscle contraction encourage lymphatic drainage. Thus the NMES is a novel intervention for improvement in the electrophysiology of peripheral nervous system.

CONCLUSION:

NMES training method is efficient for alternate exercise method to maintaining the electrophysiology of nervous system and can induce greater change in the DNP and blood glucose level, blood pressure. Body fat for the T2DM Patients, who might have difficulties in performing adequate voluntary exercise. In the future it would be interesting to compare different intensities of voltage, frequency and duration and analyze the nerve electrophysiological properties during diabetic condition.

REFERENCES:


