"A COMPARATIVE STUDY BETWEEN EFFECTIVENESS OF HIGH INTENSITY INTERVALTRAINING VERSUS ANAEROBIC TRAINING FOR IMPROVING GAIT ENDURANCE AND FOOT FUNCTION DISABILITY IN DIABETIC NEUROPATHY PATIENTS"

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ABSTRACT

BACKGROUND: Diabetic neuropathy is the most common ailment of the people diagnosed with diabetes mellitus. Especially it is characterised by pain and loss of function and changes in the gait. Physiotherapy has been a great choice of treatment for such pain. Recent articles support the use of High Intensity Interval Training Versus Anaerobic Training for the treatment of Diabetic neuropathy.
AIMS AND OBJECTIVES: To compare effectiveness of high intensity interval training versus anaerobic training for improving gait endurance and foot function disability in diabetic neuropathy patients in terms of foot function index
METHODOLOGY: 30 Participants after being screened for eligibility criteria divided into 2 groups by simple random sampling. Group 1 received intervention in the form of high intensity training along with their regular training, Group 2 received regular training with Aerobic training exercises over the course of 12 weeks. Effectiveness Parameters were improvement in Shuttle walk test and foot function index. They were assessed at baseline and at the end of the study. Post intervention data was analysed using SPSS software using t test and ANOVA.
RESULT: There was significant difference in parameters in all the groups from baseline and end of the study ($p<0.001$).However High intensity interval training along with their regular training was superior to the change of outcomes like Shuttle walk test and foot function index.

CONCLUSION: The result of this study demonstrates High intensity interval training along with their regular training statistically improves the Shuttle walk test and foot function index.

KEY WORDS: Interval training , Diabetic neuropathy, High intensity

INTRODUCTION

Diabetic neuropathy is a type of nerve damage that can occur if you have diabetes. High blood sugar can injure nerves throughout the body. (1,2) Diabetic neuropathy most often damages nerves in the legs and feet. Depending on the affected nerves, diabetic neuropathy symptoms include pain and numbness in the legs, feet and hands. It can also cause problems with the digestive system, urinary tract, blood vessels and heart, diabetic neuropathy can be quite painful and disabling. (2,3)

Diabetic neuropathy is a serious diabetes complication that may affect as many as 50% of people with diabetes. But it can often prevent diabetic neuropathy or slow its progress with consistent blood sugar management and a healthy lifestyle. (3,4) There are four main types of diabetic neuropathy.
Peripheral neuropathy
Autonomic neuropathy
Proximal neuropathy (diabetic polyradiculopathy)
Mononeuropathy (focal neuropathy)
Diabetic nephropathy is the leading cause of chronic kidney disease in patients starting renal replacement therapy and is associated with increased cardiovascular mortality. Diabetic nephropathy has been classically defined by the presence of proteinuria 0.5 g/24 h. This stage has been referred to as overt nephropathy, clinical nephropathy, proteinuria, or macro albuminuria. (7,8,9). In the early 1980s, seminal studies from Europe revealed that small amounts of albuminin the urine, not usually detected by conventional methods, were predictive of the later development of proteinuria in type 1 (3–5) and type 2 (6) diabetic patients. This stage of renal involvement was termed micro albuminuria or incipient nephropathy. The cumulative incidence of micro albuminuria in patients with type 1 diabetes was12.6% over 7.3 years according to the European Diabetes (EURODIAB) Prospective Complications Study Group and 33% in an18-year follow-up study in Denmark. (10) In patients with type 2 diabetes, the incidence of micro albuminuria was 2.0% per year and the prevalence 10 years after diagnosis 25% in the U.K. Prospective Diabetes Study (UKPDS). Proteinuria occurs in 15– 40% of patients with type 1 diabetes, with a peak incidence around 15–20 years of diabetes. In patients with type 2 diabetes, the prevalence is highly variable, ranging from 5 to 20%. Diabetic nephropathy is more prevalent among African Americans, Asians, and Native Americans than Caucasians. Among patients starting renal replacement therapy, the incidence of diabetic nephropathy doubled from the years 1991–2001.Fortunately, the rate of increase has slowed down, probably because of the adoption in clinical practice of several measures that contribute to the early diagnosis and prevention of diabetic nephropathy, which thereby decreases the progression of established renal disease. (11,12,13)
The biomechanics of the diabetic foot is different from that of the non-diabetic foot. Fundamental changes occur in the overall gait with specific maladaptive processes occurring in the diabetic foot. 1 These maladaptive processes are both structural and functional in nature. Joint immobility plays a pivotal role in the faulty biomechanics of the foot and ankle in the diabetic patient. Structural changes occur within the tendon and capsule of the diabetic patient disorganized pattern emerges in the diabetic tendon, capsule, and ligament. 5,7,8 These changes lead to decreased elasticity and tensile strength. This may not be problematic. However, these changes lead to either instability at joints causing subluxations or overall stiffness of the foot. In either case, the result is poor foot biomechanics. An example of an unstable diabetic foot is Charcot neuro arthropathy, which is typified by joint subluxations. The loss of normal architecture leads to the development of bony prominences on the plantar aspect of the foot causing the formation of chronic ulcerations.6 A key contributor in the Charcot neuropathy process are the changes that occur in the Achilles tendon resulting in an equinus deformity.9 An equinus deformity is defined as a contracture of the Achilles tendon. The upward force of the Achilles tendon during propulsion, in an environment of a contracture, causes a break or subluxation in the midfoot. At the other end of the spectrum, a stiff or immobile foot caused by joint capsule contracture is also maladaptive causing focal areas of high pressure, which again leads to the formation of chronic ulcerations. Aerobic training can improve movement and mobility and decrease pain in people who are suffering from diseases that impair the ability to move the body, such as arthritis and fibromyalgia. Lower disease risk. Aerobic training can reduce the risk of various diseases, including heart

disease, stroke, high blood pressure, high cholesterol, diabetes, metabolic syndrome, and certain types of cancer. Overweight/obesity. Aerobic training can help to lower body fat levels or improve body composition. Blood sugar. Aerobic training can improve blood sugars and improve the use of insulin in the body. Psychological stress. (13) Aerobic training on a regular basis may reduce the symptoms associated with depression, improve mood, and enhance mental well-being. Brain. Aerobic training can improve memory and thinking skills as well as protect against cognitive decline in the aging process. Thus, this study will focus on the effect of high intensity interval training and aerobic exercises on the foot function index and duration of the shuttle walk test in patients with diabetic neuropathy. (22)

PROCEDURE

After collecting the written consent form the patients selected by inclusion and exclusion criteria, they were divided into two group- group A and group B. Group A will be treated with High intensity interval training (HIIT) and Group B will be treated with Anaerobic training. GROUP A patient were given high intensity interval training program three days a week for 12 weeks. Session time –40 to 45 min.

Group A Exercise:

High-intensity interval training protocol was divided into 3 phases according to phase 1: weeks 1–2, phase 2: weeks 3–4, phase 3: weeks 5–8.

In phase 1, participants warmed up for 5 min, increasing intensity gradually to reach 50% of maximal heart rate. It was maintained for 20 min and then followed by a recovery period of 5 min.

In phase 2, there was a 5-min warm up to reach 50% maximum heart rate (HRmax), and it was followed by 1-minute sprint at 80% HRmax, then slowing down intervals at 50% HRmax for 5 min. This procedure was repeated three more times and then followed by a recovery phase of 5 min.

In phase 3, the protocol was longer and more intense. After a 5-minute warm-up to 60% HRmax, patients performed six 1-minute sprints at 85% HRmax, followed by 4-minute slowdown intervals at 50%. The whole session lasted 40 min. At the end of each 1 min sprint, exercise intensity was also assessed through Borg RPE scale (rate of perceived exertion), which was independent from the heart rate. The participants of HIIT were rated as 7–8 as they informed a really hard activity, as they could speak short sentences, but could not hold a conversation

Group B Exercise

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 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 no 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 1x20repetition.

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.36

• Standing on heels and toes.

• These exercises were performed for 3 times, each for 30sec.

• Balance training started by opened then closed eyes.

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 of rest .

RESULT AND DATA INTERPRETATION

After screening of the 90 patients for study eligibility, a total of 30 patients were selected for Analysis from which 15 were in the Group A (High Intensity Interval Training) and 15 were in the Group B (Anaerobic Exercise). Analysis Pre- test and Post test score within and between the values of groups are given with intervention of the result of the study. The sample consisted of both male and female there were 11 males and 19 females. The following chart shows the gender distribution in the sample

Following are the values of the variables pre and post interventions.

VARIABLE		MEAN	SD	P
FFI	PRE	6.06	2.26	<0.05
	POST	2.53		
ESWT	PRE	60.66	22.67	<0.05
	POST	25.33		

GROUP 1: MEAN AND SD of High Intensity Interval Training group pre and post variables

The mean and SD are 6.06 and 2.26 for FFI and for ESWT they are 60.66 and 25.33 respectively. The p value being less than 0.05 it shows statistically significant difference

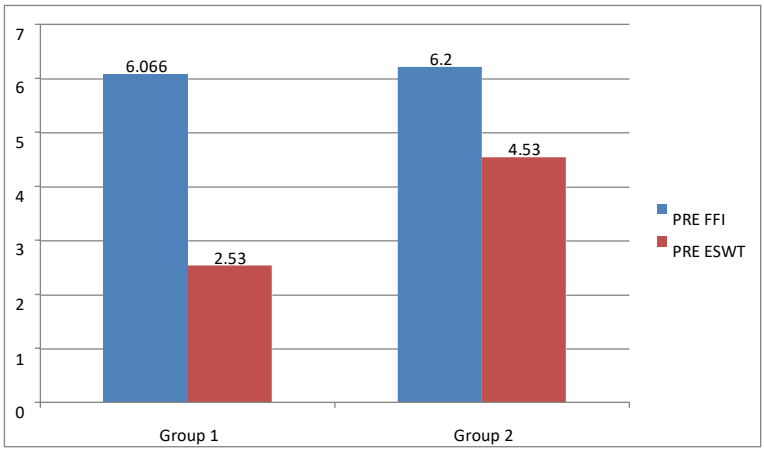


Figure 3: Mean difference in VAS score in both the groups.

VARIABLE		MEAN	SD	P
FFI	PRE	6.2	0.29	<0.05
	POST	4.5		
ESWT	PRE	62	2.99	<0.05
	POST	45.33		

GROUP 2:: MEAN AND SD of Anaerobic group pre and post variables
The mean and SD are 6.2 and 4.5 for FFI and for ESWT they are 62 and45.33 respectively. The p value being less than 0.05 it shows statistically significant difference.

WITHIN GROUP:

GROUP A

ESWT	N	MEAN	SD	MEAN DIFF	DF	T	P	RESULTS
PRE-TEST	15	62.66	20.95	4	14	1.76	0.00	SIG.
POST TEST	15	45	34.9	4	14	1.76	0.00	SIG.

FFI	N	MEAN	SD	MEAN DIFF.	DF	T	P	RESULTS
PRE-TEST	15	6.06	2.2	4	14	1.76	0.00	SIG.
POST TEST	15	4.53	3.4	4	14	1.76	0.00	SIG.

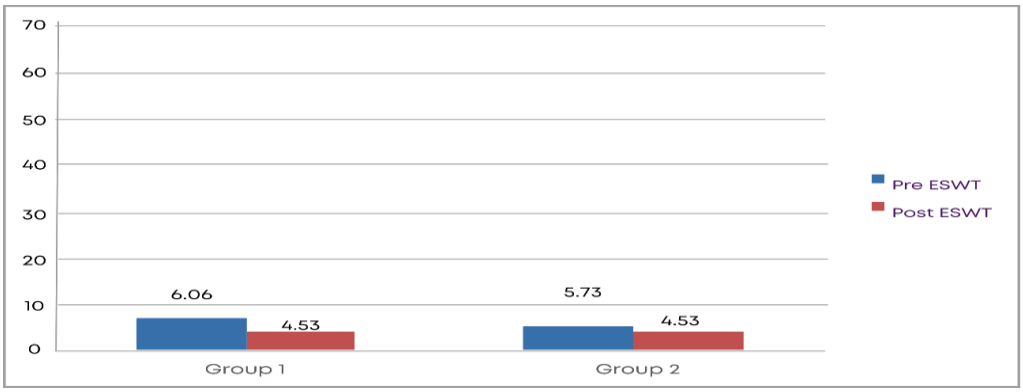
INTERPRETATION: From the values obtain by performing the students t test on the sample within the groups. The obtain mean for Pre-test and Post-test are 6.06 and 4.53. Whereas for ESWT they are 62.66 and 45 respectively. The T value being 1.76 and p is <0.05 showing statistically significant difference. There has been statistically significant improvement in both the outcomes post intervention.

GROUP B:

FFI	N	MEAN	SD	MEAN DIFF.	DF	T	P	RESULTS
PRE TEST	15	5.73	4.6	4	14	1.76	0.03	SIG.
POST TEST	15	4.53	3.4	4	14	1.76	0.03	SIG.

ESWT	N	MEAN	SD	MEAN DIFF	DF	T	P	RESULTS
PRE SPADI	15	62	217	4	14	1.76	0.00	SIG.
POST SPADI	15	45.3	340	4	14	1.76	0.00	SIG.

INTERPRETATION: From the values obtain by performing the students t test on the sample within the groups. The obtain mean for Pre-test and Post-test are 5.73 and 4.53. Whereas for SPADI they are 62.66 and 45.3 respectively . The T value being 1.76 and p is <0.05 showing statistical significant difference. There has been statistical significant improvement in both the outcomes post intervention.



BETWEEN THE GROUPS:

TEST	N	MEAN	SD	MEAN DIFF.	DF	T	P	RESULTS
GROUP A	30	35.33	126.6	18.67	28	1.76	0.03	SIG.
GROUP B	30	16.66	238.0	18.67	28	1.76	0.03	SIG.

INTERPRETATION: From the values obtain by performing the students t test on the sample within the groups. The obtain mean for Pre-test and Post-test are 35.33 and 16.66.The T value being 1.76 and p is <0.05 showing statistical significant difference. There has been statistical significant improvement in both the outcomes post intervention.

RESULT OF THE STUDY:

The present study resulted that both groups showed significant effect of treatments within group were effective on DIABETIC NEUROPATHY PATIENTS On comparison of both groups. High Intensity Interval Training statistically improves the diabetic neuropathy in terms of Foot Function Index and Shuttle Walk Test.

DISCUSSION

For this study 30 subjects were taken. Randomization was done by simple chit method in to 2 groups Group A (high intensity interval training), Group B (Anerobic training) .Group A was given high intensity interval training for three days a week for 12 weeks in phasic manner, Group B was given anaerobic exercises three days in a week for 12 weeks in form of ROM, Strengthning, Balance and Gait training.

The groups in this study were heterogeneous groups with both male and female population, future studies could be done taking up a homogenous sample with literature review suggests that the incidence of diebetic neuropathy.

Both the treatment techniques in the study showed significant improvement in FFI (Foot Function Index) and ESWT (Estimated shuttle walking test). During this study following the treatment sessions the conditions improved markedly. It was noted secondarily that much milder words were being used to describe the pain and discomfort following treatments.

Group 1 showed statistical significant effect in the pain, range of motion, the disability, foot function index and shuttle walk test scores. Thus High intensity interval training with conventional therapy as an adjunct can be said to be the best treatment of choice for the patient with diebetic neuropathy.

Neuropathy of distal lower extremities is subdivided into sensory, motor and autonomic peripheral neuropathy [16]. Evidence for sensory neuropathy is a reduction or loss of vibration sense (pallhypaesthesia) and superficial sensitivity (pressure, touch) as well as subjective paraesthesia. Particularly stressful is the so-called “burning feet syndrome.” It usually arises at night and is accompanied by high sensation of pain [17].

The sensation of pain is substantially decreased as a consequence of chronic sensory neuropathy. Consequently, the risk for trauma is significantly higher [18,19,20,21]. Due to the missing pain symptomatology, serious ulcerations are underestimated by both patient and doctor [22,23]. Achilles reflex is usually reduced and often also patellar reflex. Muscular dysfunction results from the underlying neuropathy; frequently, atrophy of the anterior muscle group of lower leg exerts strain during the rollover process with an increase on forefoot pressure.

Three complications arise from the lack of sensitivity that is Constant pressure for several hour leads to local ischemic necrosis. High pressure over a short period of time leads to immediate injuries. Objects with a small surface such as nails, needles, and sharp stones etc. cause direct mechanical damage.

Repetitive moderate pressure causes inflammatory autolysis of tissue. Ongoing pressure on already inflamed or structurally affected tissue additionally promotes the development of ulcerations. Furthermore, gangrenes develop from burns with hot items such as hot-water bottles and heating blankets, excessive sunbathing, acid burn (“corn plaster”) as well as improper use of disinfection products.

Motoric neuropathy can be seen in an atrophy of small foot muscles resulting in malposition of toes (claw toe). Also, motor paresis and a loss of muscle self-reflexes are observed. Above all, loss of Achilles tendon reflex is an early sign of motor neuropathy [11,24].

Peripheral autonomic neuropathy leads to vasomotor paresis resulting in arteriovenous shunts of subcutaneous vascular network. Moreover, secretion of sweat becomes dysfunctional by sudomotor paresis due to autonomic neuropathy. Blood perfusion of deeper skin layers is increased leading to overheating of skin. Additionally, dysfunctional sweating causes lack of humidification and cooling by evaporation. As a result, foot skin dries out with the consequence of finding a reduced protective skin function and thus increased risk of injury.

Moreover, as a result of autonomic neuropathy, medial arterial sclerosis, Charcot’s foot (diabetic osteoarthropathy), neuropathic oedemas as well as alterations of skin thickness arise [21,22,20]. Medial arterial sclerosis is associated with a two-fold higher risk for ulceration and a three-fold

higher risk for amputation. Due to neuropathy, non-enzymatic glycosylation and cross-link formation of extracellular matrix impair viscoelastic foot functioning which then results in stiffness of wrist and foot joint in about 40% of patients.

Diabetic neuro-osteoarthropathy (DNOAP) or Charcot's foot is characterised by a sterile destruction of bones and joints. Due to neuropathy, the process proceeds painlessly. Visual diagnosis shows the typical reactive hyperaemia in line with swelling and destruction of osseous structures with sintering of the metatarsus region. It is easily confused with phlegmons or erysipelas. The diseased foot shows local hyperperfusion due to the neurovascular (according to Charcot) component leading to washing out and demineralization of osseous structures. As a result, bone resistance reduces fractures and bone deformity. Another theory according to Volkmann focuses on repetitive traumas as a result of continuous inappropriate stress arising from sensorimotor neuropathy. This is then followed by chronic destruction of soft tissue and osseous structures. Recent theories suggest a greater role of the nucleus transcription factor NF-κB, as well as the RANK/RANKL/OPG cytokines system (Figure).

Clinical diagnosis suspecting DNOAP includes swelling and/or erythema together with foot overheating most commonly without pain in patients with known neuropathy.

For the diagnosis of DNOAP, a conventional X-ray image to assess the 5 Ds of radiological manifestation is required that Distension of joints, dislocation of joints and bones, debris of bones, de organisation of joints and bones, density rise of bones.

In addition, it is always necessary to undergo an MRI in order to sufficiently represent cortical destruction, reaction of periosteum, sequestra and formation of gas.

According to EMILEY R COX et.el. (2020) 8-weeks of high-intensity combined aerobic and resistance exercise may be safely prescribed for inactive individuals with T2D and may reduce musculoskeletal pain but not neuropathic

Our study results are in accordance of the result of Naswa sayed hamed et.el. (2014)HIIT effective than moderate intensity aerobic training in reducing neuropathic pain, hyperglycemia, and waist circumference. However, lower extremity functional scale, body weight and body mass index did not improve significantly.

The evidence supports the ability of practice interventions to improve diabetes control. Most studies have reported that in diabetic patients with a risk factor for diabetic foot ulcers for peripheral neuropathy, it is best to perform training interventions between 8 weeks and 12 months. These studies have seen significant improvements in physical activity without increased risk of injury. If health care is incomplete, foot ulcers may develop, which is the most common cause of hospitalization and amputation .Usually, the combination of various treatments, including pharmacotherapy, physiotherapy, and orthotic devices are used to maintain biomechanical parameters, physiological patterns, and at last for wound healing.

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