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Arti Rathore
Department of Physiotherapy, Faculty of Paramedical Sciences, UPUMS, Saifai, Etawah, Uttar Pradesh, India

Gowrishankar Potturi
Department of Physiotherapy, Faculty of Paramedical Sciences, UPUMS, Saifai, Etawah, Uttar Pradesh, India

Ramakant Yadav
Department of Neurology, UPUMS, Saifai, Etawah, Uttar Pradesh, India

Neha Dubey
Department of Physiotherapy, Faculty of Paramedical Sciences, UPUMS, Saifai, Etawah, Uttar Pradesh, India

KB Ranjeet Singh Chaudhary
Department of Physiotherapy, Faculty of Paramedical Sciences, UPUMS, Saifai, Etawah, Uttar Pradesh, India

Anjali Agarwal
Department of Physiotherapy, Faculty of Paramedical Sciences, UPUMS, Saifai, Etawah, Uttar Pradesh, India

Corresponding Author:
Gowrishankar Potturi
Department of Physiotherapy, Faculty of Paramedical Sciences, UPUMS, Saifai, Etawah, Uttar Pradesh, India

The efficacy of Blood Flow Restriction Training (BFRT) and home exercise program enhancing hand grip strength in patients with diabetic neuropathy - A case study

Arti Rathore, Gowrishankar Potturi, Ramakant Yadav, Neha Dubey, KB Ranjeet Singh Chaudhary and Anjali Agarwal

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Abstract
Background: Diabetic neuropathy is a prevalent complication among patients with diabetes, characterized by nerve damage, particularly in the peripheral nerves. This may lead to muscle weakness, diminished hand grasp quality, and impeded movement of everyday living, essentially influencing quality of life. Recent studies suggest that Blood Flow Restriction Training (BFRT), a technique involving low-load resistance exercises combined with partial occlusion of blood flow, can improve muscle strength effectively with lighter loads, making it a possibly secure elective for those with diabetic neuropathy.
Aim of the study: To evaluate the efficacy of Blood Flow Restriction (BFR) training in enhancing hand grip strength in patients with diabetic neuropathy and to explore its potential as a possible therapeutic approach for improving functional hand performance and overall quality of life in this population.
Methodology- A 65 years old male with a 15 years history of Type-2 diabetes and a 5 months history of Diabetic Neuropathy. Patient Complaints difficulty in holding objects, feeling tingling and numbness in both hands, pain, limiting his ability to perform Activities of Daily Living (ADLs) last 5 month. At base line score were hand function score 60/80, hand grip strength (measured by hand dynamometer) 18 kg in Dominant hand and 15 kg in non-dominant hand, NPRS 50 /100 and CAP-PRI 15/30 underwent 12 sessions of BFRT over one month (4 weeks) combined with Low Load Resistance Training targeted the hand grip strength in diabetic neuropathy patient including home exercises program.
Result-After 4 weeks of BFRT and low-load resistance training, the following outcomes were observed: hand function score 76/80, hand grip strength (measured hand dynamometer) 27 kg in Dominant hand and 19 kg in non-dominant hand, NPRS 9 /100 and CAP-PRI 3/30**.** The patient noted better hand control, improved grip stability, and increased confidence in daily activities such as carrying groceries, holding utensils, and butting.
Conclusion: This case study highlights the potential of BFR training as an effective intervention for patients with diabetic neuropathy. Further research with larger sample sizes is recommended to confirm these findings and establish standardized protocols for clinical use.

Keywords: Diabetes mellitus, diabetic neuropathy, hand grip strength, BFRT (Blood flow restriction training)

Introduction
Diabetes Mellitus (DM): Diabetes Mellitus (DM) is a group of metabolic illnesses in which a person has high blood sugar, either because the body does not create enough insulin, or because cells do not respond to the insulin that is supplied. DM has been classified into two types

- **Type I:** Insulin Dependent Diabetes Mellitus (IDDM) and
- **Type II:** Non-insulin Dependent Diabetes Mellitus (NIDDM).

Diabetes mellitus increases the risk of numerous consequences, including peripheral and cardiovascular illnesses, stroke, neuropathy, renal failure, retinopathy, blindness, and amputations [1].

According to World Health Organization (WHO) "A chronic, metabolic disease characterized by elevated levels of blood glucose (or blood sugar), which leads over time to serious damage to the heart, blood vessels, eyes, kidneys, and nerves. There are types of diabetes are type 1 diabetes, type 2 diabetes, and gestational diabetes".

According to WHO, In India, there are assessed 77 million individuals over the age of 18 years are enduring from diabetes (type 2) and about 25 million are prediabetics (at a better chance of creating diabetes in close future). More than 50% of individuals are ignorant of their diabetic status which leads to wellbeing complications in case not recognized and treated early.

The current studies predict an increment within the predominance of grown-ups with diabetes is expected to rise from 4% in 1995 to 6.4% in 2025 all inclusive [2].

Diabetic neuropathy: Approximately 50% of people with diabetes mellitus develop diabetic neuropathy, one of the most common forms of the disease [3]. Hand function and grip strength are greatly impacted by this neuropathy, which frequently results in a range of motor and sensory impairments [4]. In diabetic populations, decreased grip strength is linked to higher rates of morbidity and mortality in addition to impairing day-to-day functioning [5]. Therefore, effective treatment protocols are needed to improve hand function in diabetic neuropathy patients to improve their quality of life.

Clinical manifestation: The symptoms usually develop gradually over the year-

- Numbness and tingling of extremities
- Decrease or lost sensation to a body parts (dysesthesia)
- Weakness of muscles
- Fasciculation
- burning or electric pain [6]

Blood flow restricted training: Blood Flow Restriction (BFR) is a training technique that involves partially restricting arterial inflow and restricting venous outflow in the working muscles during exercise. The first person in Japan to employ exercise that constricts the capillaries close to the muscle, lowering blood flow, was Dr. Yoshiaki Sato. This technique was known as "kaatsu training," which translates to "training with added pressure." Nowadays, kaatsu training, sometimes referred to as "BFR training," is performed with a pneumatic tourniquet all over the world [7].

Recent studies indicate that BFR training can effectively enhance muscle strength in various populations, including the elderly and those with certain chronic conditions[8]. However, research specifically addressing its efficacy in patients with diabetic neuropathy remains limited. This study aims to determine the effects of BFR training on hand grip strength in patients diagnosed with diabetic neuropathy. We hope to elucidate the most effective strategy for improving grip strength, thereby enhancing functional capabilities and overall quality of life in this population.

Blood Flow Restriction Training (BFRT): This technique involves the application of a tourniquet or cuff to the proximal limb to partially restrict venous blood flow while allowing arterial inflow during exercise. BFRT has been shown to elicit similar hypertrophic and strength gains to traditional resistance training despite lower training intensities [9-10].

Operational Definition of Blood Flow Restriction Training (BFRT)

The strength training method called Blood Flow Restriction Training (BFRT) blocks venous blood flow while allowing arterial flow using a band or pneumatic cuff. This reduces the amount of oxygen available to working muscles during low-intensity resistance training. This induces metabolic stress and muscular adaptations similar to those achieved through high-intensity resistance training [10].

Objective of the study

To evaluate the effectiveness of the Blood Flow Restriction Training (BFRT) in improving hand grip strength in patient with Diabetic Neuropathy.

Aim of the study

To assess Blood Flow Restriction (BFR) training's effectiveness in strengthening hand grips in diabetic neuropathy patients and investigate its potential as a workable treatment strategy for enhancing functional hand performance and general quality of life in this population.

Methodology

Study design: This case study involves a single patient (case 1), treated over 4 weeks, with outcome measurement at base line, at 2 week and at 4 weeks of intervention. The effectiveness of BFRT combined with Low load resistance training and a prescribed home exercise program was evaluated.

Participant selection source: Diabetic Neuropathy patient was screened for eligibility from the Neurology OPD of UPUMS, Saifai, Etawah. After satisfying inclusion and exclusion criteria, the patient was enrolled in the study.

Table 1: Participant selection criteria

Inclusion criteria	Exclusion criteria
1. Patients diagnosed with Diabetic neuropathy.	1. History of cardiovascular diseases or contraindications to exercise.
2. Age- 40- 65 years.	2. Blow 40 years and above 65 years
3. Documented hand grip strength deficits, as measured by a dynamometer.	3. Uncontrolled diabetes or other contraindications to exercise.
4. Ability to provide informed consent.	4. History of musculoskeletal injuries in hand grip strength outcomes.
	5. Severe peripheral vascular disease (DVT, varicose vain, Raynaud's disease etc.)

Intervention protocol

This protocol was designed for the treatment of diabetic neuropathy, focusing on hand grip strength, pain, and functional disability. The entire treatment process was sufficiently explained & voluntary agreement was obtained before the delivery of the treatment. A detailed history was taken, and a present data form was filled out by the patient. Past history of illness & any systemic disease was inquired about cautiously. A complete physical examination includes a general physical examination and handgrip strength.

The treatment protocol consisted of the following components

BFRT + Low load resistance training + Home exercise Programme

The BFRT exercise program consisted of low-intensity resistance training and limb blood flow restriction. The patient was given BFRT with resistance training. The patient

was sitting in a comfortable position. The calibrated pneumatic cuff (size 10-12 cm U/L) was applied proximal to the forearm. After measuring the blood pressure of the patient, we multiply the systolic blood pressure by 1.2. The resultant blood pressure was given during BFRT with resistance training (less than 15 min.) according to the Australian Sports Commission guidelines, and then we release the pressure and give 5 min. for tissue reperfusion. Including exercises such as wrist flexion and extension with a weight cuff (20% of one-repetition maximum) in a sitting position, 4 sets of 30, 15, 15, 15, and 30 sec. rest between sets, and two repetitions were done with an interval of 5 min. 3 sessions per week for 4 weeks, with each session lasting approximately 30 minutes.

<table>
<tr><td rowspan="2">Inflation and pressurization</td><td colspan="7">Performing BFRT with 40% of limb occlusion pressure and a resistance load of 20 % 1-RM (Australian sports commission guidelines) for four sets Blood flow restriction time of 6.5 minutes.</td><td rowspan="2">Complete deflation 5 minutes (Australian sports commission guidelines)</td><td rowspan="2">Resistance training on the hand muscle (flexion, extension of the wrist with weight cuff)</td></tr>
<tr><td>1st set 30 times</td><td>Rest 30 sec</td><td>2nd set 15 times</td><td>Rest 30 sec</td><td>3nd set 15 times</td><td>Rest 30 sec</td><td>4nd set 15 times</td></tr>
<tr><td colspan="10">Warm up: 5 minutes - BFRT: 10 minutes × 2(20 minute) - stretching: 5 minutes, the total exercise time is 30 minutes [11-12]</td></tr>
</table>

Warm-up exercise: elbow and wrist flexion and extension (10 repetitions).
Stretching- Hand and finger stretching (Intrinsic and extrinsic muscles of hand).
Home exercise will be advised, such as

Squeeze ball exercise
Each patient was instructed to sit and squeeze the ball and wait for 10 seconds. (10 repetitions, 3 times a day)

Rubber band exercise
a) Each patient was instructed to sit with their shoulder in a neutral position and both their elbow and finger (Metacarpophalangeal joint) were flexed. A rubber band will be wrapped around the patient's fingers, and the patient will be asked to perform finger extension. (10 repetitions, 3 times a day)
b) The patient was asked to sit with his shoulder in a neutral position, elbow flexed, and forearm pronated. Then a rubber band was wrapped around his fingers, and the patient was asked to do abduction of the fingers.[12] (10 repetitions, 3 times a day)

Procedure
- The patient diagnosed with diabetic neuropathy came to the physiotherapy OPD from the reference of the neurology department.
- Check for the inclusion criteria.
- Baseline assessment.
- Clinical evaluation of the patient's hand grip strength using tools such as a hand dynamometer and hand function using tools such as a hand function test scale.
- Pain levels were measured using NPS.
- Quality of life and ADL were evaluated using the Chronic Acquired Polyneuropathy Patient-Reported Index (CAPPRI) questionnaire.
- Preparation: Obtain informed consent from the patients, explaining the procedure for BFRT.

Fig 1: Patients with BFRT + low load resistance training

Case description

A 65 years old male with a 15 years history of Type-2 diabetes and a 5 months history of Diabetic Neuropathy. Patient Complaints difficulty in holding objects, feeling tingling and numbness in both hands, pain, limiting his ability to perform Activities of Daily Living (ADLs). After meeting the inclusion and exclusion criteria, the treatment plan was thoroughly explained and a written consent was obtained from the patient. He agreed to patient in the study and attends follow-up sessions. He was treated with BFRT with low load resistance training and home exercise program was explained to his at the base line treatment and ask he to perform Squeeze ball exercise (10 repetitions, 3 times a day), Rubber band exercise (10 repetitions, 3 times a day) for 4 weeks. He received then same treatment protocol thrice a week for 4 weeks. After 2 week and 4 week of intervention, outcome measures were assessed using Neuropathic Pain Scale (NPS) for pain, hand grip strength though hand dynamometer and Quality of life and ADL was evaluated using the Chronic Acquired Polyneuropathy Patient-Reported Index (CAPPRI) questionnaire, for functional disability.

Base line assessment

On observation

Skin condition

Dryness: No
Discolouration: No
Ulcer: No
Swelling: No
Muscles wasting: No

On palpation

- **Temperature:** Normal
- **Tenderness:** No
- **Swelling:** No
- **Pulse:** 82 bpm
- **HR:** 14 bpm
- **BP:** 140/80 mmhg

On examination

Blood sugar level

Fasting: 104 mg/dl
P.P.: 156 mg/dl
HbA1c: 5.7%

Weight: 52 kg; **Height:** 1.647 m; **BMI:** 19.17

- **Hand grip strength (Baseline):** 18 kg on the dominant hand, 15 kg on the non-dominant hand (measured using a hand dynamometer).
- **Pain:** Moderate discomfort on the Neuropathic Pain Scale (NPS) -50/100
- **Hand function:** Limited hand function. The hand function score was 60/80.
- **Quality of life and ADL:** Chronic Acquired Polyneuropathy Patient-Reported Index (CAPPRI) questionnaire. The baseline was 15/30.Intervention:

A 4-week BFRT protocol was designed, combining low-load resistance exercises targeting hand grip muscles. Training was performed thrice weekly, with the following specifics:

1. Blood flow restriction protocol

The calibrated pneumatic cuff (size 10-12 cm U/L) was applied proximal to the forearm after measuring the blood pressure of the patient; we multiply the systolic blood pressure by 1.2. The resultant blood pressure was given during BFRT to create partial occlusion. The pressure was adjusted each session based on the patient's tolerance and blood pressure readings.

2. Resistance training protocol

- **Exercises:** Wrist flexion/extension exercises with a low-load resistance (20% of the patient's one-repetition maximum).
- **Sets/Reps:** 4 sets of 30, 15, 15, and 15, with 30-second rest intervals between sets and two repetitions with 5-minute rests between repetitions.

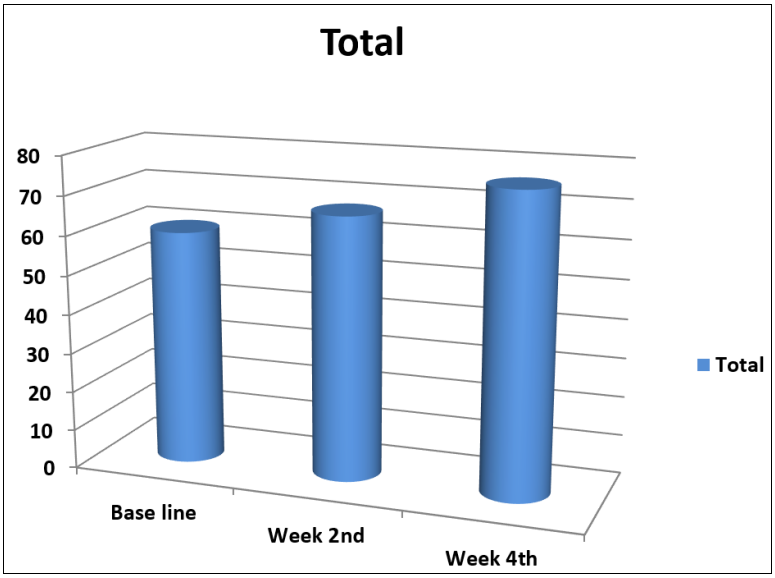
Outcomes measurements: Baseline, at the end of 2nd and 4th weeks, several parameters were re-assessed.

Hand function test

Table 2: Scoring 0 to 4 (0- Cannot perform the task, 4- Performs normally)

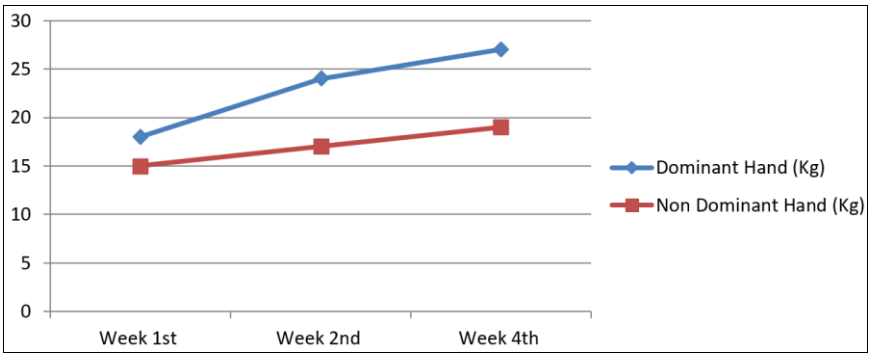
Sr. No.	Parameter	Score (0-4)		
		Base line week 1st	Week 2nd	Week 4th
1	Put key into Yale lock, turn 90"	4	4	4
2	Pick coins up from flat surface, put into purses mounted on wall	4	4	4
3	Open/close zip	3	3	4
4	Pick up coins from purses	3	4	4
5	Lift wooden cubes over edge 5 cm in height	2	2	3
6	Lift iron over edge 5 cm in height	3	3	4
7	Turn screw with screwdriver	3	3	4
8	Pick up nuts	3	4	4
9	Unscrew lid of jars	2	3	4
10	Do up buttons	1	2	3
11	Cut modelling clay with knife and fork	2	2	3
12	Put on Tubigrip stocking on the other hand	3	3	3
13	Write with pen	3	4	4
14	Fold paper, put into envelope	4	4	4
15	Put paper-clip on envelope	4	4	4
16	Lift telephone receiver, put to ear	4	4	4
17	Turn door handle 30"	3	4	4
18	Pour water from 1 litre paper milk package Pour	3	3	4
19	Pour water from jug	3	3	4
20	Pour water from cup	3	4	4
Total scoring		60	67	76

- **Baseline:** Average score: 60/80 (difficulty performing some tasks).
- **Week 2nd:** Average score 67/80(difficulty performing some tasks).
- **Week 4th:** Average score: 76/80(tasks performed with ease)



Hand grip strength: Grip strength increased to 27 kg on the dominant hand and 19 kg on the non-dominant hand, showing a significant improvement from baseline measurements.

Parameters	Dominant hand Kg	Non-dominant hand Kg
Week 1st	18 kg	15 kg
Week 2nd	24 kg	17 kg
Week 4th	27 kg	19 kg



Hand grip strength: Improvement shown in graphical form

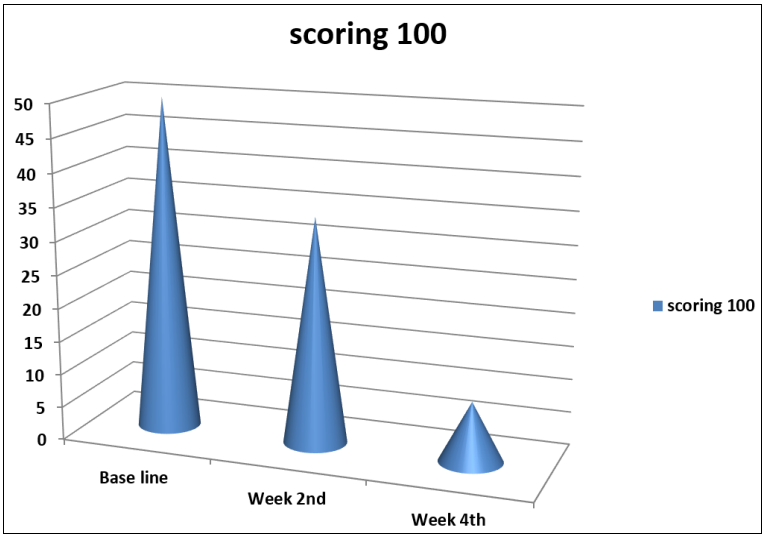
- **Pain and function scale:** The patient reported a reduction in pain (NPS: 3/100) and improved hand function, reflected by a decrease in the hand function test.

Aggravating factor - Pain aggravate in activity
Relieving factor - Rest

- 0 = No pain or sensation
- 10 = The most intense pain or sensation imaginable

S. No.	Parameter	Description	Score (0-10)		
			Base line (Week 1st)	Week 2nd	Week 4th
1	Pain Intensity	Overall severity of the pain.	5	4	2
2	Sharp Pain	Intensity of sharp, stabbing pain.	3	2	0
3	Hot/Burning Pain	Intensity of burning sensation in the affected area.	3	2	0
4	Cold Pain	Intensity of cold sensation causing discomfort.	5	4	1
5	Dull Pain	Intensity of deep, aching pain.	5	3	1
6	Itching	Severity of itching sensation.	4	4	0
7	Tingling	Severity of tingling or "pins and needles" sensation.	9	5	1
8	Numbness	Perception of reduced sensation or numbness in the affected area.	8	5	1
9	Electric-shock-like Pain	Intensity of sudden, jolting pain resembling an electric shock.	4	3	2
10	Unpleasantness	Overall unpleasantness of the pain, irrespective of intensity.	4	2	1
Total Score			50	34	9

Week 1st - 50/100 (Severe neuropathic Pain)
Week 2nd -34/100 (Moderate neuropathic Pain)
Week 4t - 9/100 (Mild neuropathic Pain)

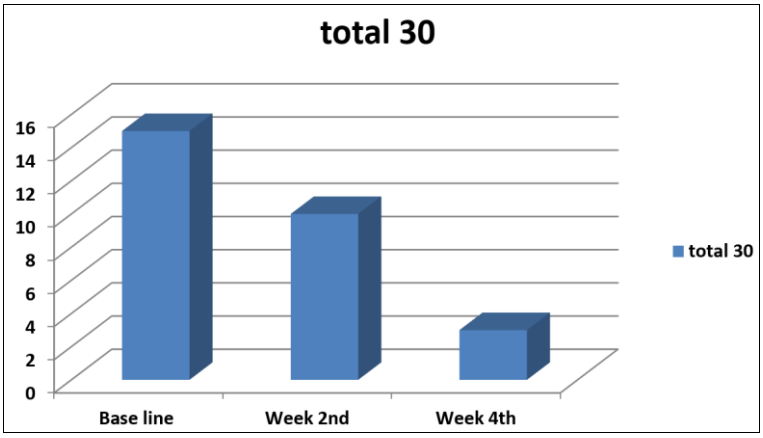


Pain: Improvement shown in graphical form

Quality of life and ADLs: The patient reported increased confidence in performing ADLs, reduced hand numbness, and improved quality of life by using Chronic Acquired Polyneuropathy Patient-Reported Index (CAPPRI) questionnaire.

Session Details	Base line (1st week)			2nd week			4th week		
Patient's Instructions	Not at all (0)	A little bit (1)	A lot (2)	Not at all (0)	A little bit(1)	A lot (2)	Not at all (0)	A little bit (1)	A lot (2)
1. I frustrated by my neuropathy.		1			1				
2. I am bothered by pain from neuropathy.		1			1				
3. I am off balance when walking because of my neuropathy.	0			0					
4. I have trouble getting dressed because of my neuropathy.			2		1			1	
5. I have trouble sleeping because of my neuropathy.			2		1			1	
6. I am bothered by limitations in performing my work (include work at home) because of my neuropathy.			2		1				
7. I have trouble driving because of my neuropathy.		1			1				
8. I am depended on others because of my neuropathy.	0		0	0				1	
9. I am depressed about my neuropathy.		1			1				
10. I am falling because of my neuropathy.	0			0					
11. I am preoccupied with my neuropathy		1		0					
12. I am unable to do all the leisure activities that I want to do because of my neuropathy.		1			1				
13. I am worn out because of my neuropathy.			2		1				
14. I have trouble eating because of my neuropathy.	0			0					
15. I have trouble doing activities around the house.		1			1				
Total score	15			10			3		

Week1st -15 /30
Week 2nd -10/30
Week 4th - 3/30



Result

After 4 weeks of BFRT and low-load resistance training, the following outcomes were observed:

- **Hand grip strength**
  - Increased from 60/80 to 76/80.

- **Hand grip strength**
  - Dominant hand (Right) grip strength increased from 18 kg to 27 kg.
  - Non-dominant hand (Left) grip strength increased from 15 kg to 19 kg.

- **Pain and functional assessments**
  - The patient reported a significant reduction in pain, with NPS (Neuropathic Pain Scale scores decreasing from 50/100 to 9/100.

- **Quality of life and ADL**
  - The patient reported a significant Improvement with The Chronic Acquired Polyneuropathy Patient-Reported Index (CAP-PRI). CAP-PRI scores decreasing from 15/30 to 3/30.

The patient noted better hand control, improved grip stability, and increased confidence in daily activities such as carrying groceries, holding utensils, and buttoning.

Discussion

The findings of this case study demonstrate that blood flow restriction training significantly improves hand function and hand grip strength, reduces neuropathic pain, and enhances quality of life in a patient with diabetic neuropathy. BFR training's low-intensity nature makes it particularly suitable for patients who may not tolerate traditional resistance training. The improvement in hand function and grip strength suggests better engagement in daily activities, contributing to an improved overall quality of life.

Conclusion

This case study highlights the potential of BFR training as an effective intervention for patients with diabetic neuropathy. Further research with larger sample sizes is recommended to confirm these findings and establish standardized protocols for clinical use.

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