

Effectiveness of Aqua - Aerobic Exercise and Proprioceptive Neuromuscular Facilitation in Improving Upper and Lower Limb Flexibility for Type II Diabetes Mellitus Patients

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Abstract: ***Background:** Type II diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and high blood sugar levels. Impaired flexibility is a common complication of T2DM, increasing the risk of musculoskeletal issues and reducing overall functionality. Aqua aerobic exercise and proprioceptive neuromuscular facilitation (PNF) have been explored as potential interventions to improve upper and lower limb flexibility in Type II diabetes mellitus patients. **Aim and Objectives:** To find out the effectiveness of aqua aerobic exercise and proprioceptive neuromuscular facilitation (PNF) to improve upper and lower limb flexibility in type II diabetes mellitus. **Methodology:** The studies involved Type II diabetes mellitus patients aged 40 - 60 years and assessed the effects of aqua aerobic exercise and proprioceptive neuromuscular facilitation on upper and lower limb flexibility. The outcomes measured included sit and reach and back scratch test for upper and lower limb flexibility. **Results:** The pre test and post test of group A and B values were assessed by sit and reach test in 20 patients for type II diabetes mellitus. The mean difference 7.4 and 4.4 respectively, the standard deviation value is 1.34 and 1.17 respectively. The paired 't' test value is 17.34 and 11.85 more than table value of 2.262 respectively. The unpaired 't' test value is 5.94 more than table value of 2.09. The pre test and post test values of group A and B were assessed by back scratch test in 20 patients for type II diabetes mellitus. The mean difference 2.1 and 1.13 respectively, the standard deviation value is 0.65 and 0.41 respectively. The paired 't' test value is 10.08 and 8.69 more than table value of 2.262 respectively. The unpaired 't' test value is 3.95 more than table value of 2.09 and thus it denotes the significance. These results suggest that aqua aerobic exercise is more effective than proprioceptive neuromuscular facilitation (PNF) stretching in improving upper and lower limb flexibility for type II diabetes mellitus patients.*

Keywords: Type II diabetes mellitus, flexibility, Aqua aerobic exercise, Proprioceptive neuromuscular facilitation (PNF) stretching

1. Introduction

Type II diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and high blood glucose levels. It affects millions of people worldwide and can lead to various complications, including reduced flexibility in the upper and lower limbs is a common problem. Limited flexibility in T2DM patients can significantly impair their ability to perform daily activities and impact their overall quality of life.

Collagen, the rubbery substance that gives joints their mobility, becomes "glycated" as a result of high blood sugar levels. Glycated simply implies sugar - coated. Glycation results in collagen forming sticky nets, which reduces the flexibility of joints.

Aqua aerobics exercise involves performing aerobic or resistance exercises in a pool. It enhances flexibility, blood glucose control in people with type II diabetes mellitus by lowering fasting blood glucose levels. The buoyancy of water reduces the impact on joints, making it an attractive exercise option for individuals with reduced flexibility. Several studies have investigated the effect of aqua aerobics exercise on flexibility in T2DM patients.

According to Antonela nedic and Amatyakul S et. al study, Aquatic aerobic exercises have extensive biological

effects that span across nearly all homeostatic systems. Due to the advantages of hydrostatic forces (buoyancy) and drag resistances specific to the water medium, aquatic environments are advantageous in the management of a number of musculoskeletal, neurological, and cardiac disorders. In sedentary patients with type II diabetes mellitus who are unaccustomed to exercise and wish to begin a training programme, the training carried out in water may minimise some of the dangers of exercise, such as joint tendon strains or trauma.

Proprioceptive neuromuscular facilitation (PNF) is a stretching technique that involves alternating contraction and relaxation of muscles to improve flexibility. Various studies have investigated the effectiveness of PNF in improving flexibility in T2DM patients.

According to Jaya Shanker Tedla and kayla B. hindle et. al study proprioceptive neuromuscular facilitation (PNF) focuses on achieving the ideal balance between mobility and stability in order to enhance strength, coordination, and control of movements. . Some studies show that stretching can also help improve flexibility and blood sugar levels in people with type II diabetes. It has been suggested that stretching can help improve circulation in the small blood vessels in the muscles and joints, allowing glucose to enter cells more easily. Daily stretching is strongly recommended to improve health and quality of life.

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It is essential to address the issue of limited flexibility in T2DM patients as it can have far - reaching consequences for their daily functioning and long - term health outcomes. By exploring the effectiveness of aqua aerobic exercise and proprioceptive neuromuscular facilitation (PNF) in improving upper and lower limb flexibility, this study aims to contribute to the growing body of knowledge in diabetes management and rehabilitation strategies. Ultimately, such interventions could help enhance the flexibility, quality of life and overall health of individuals with Type II diabetes mellitus.

2. Materials and Methodology

Material Used:

- Assessment form
- Stethoscope
- Sphygmomanometer
- Pulse oximeter
- Pool
- Stepper
- Ball
- Kick board
- Styrofoam Noodle
- Water dumbbell
- Pillow
- Blanket
- A towel
- Swim cap
- A pair of goggles
- Measuring portion or yardstick
- Ruler

Methodology

- All patients underwent an HbA1c level between 6.5 to 9 are included.
- Sit and reach scale for lower limb and back scratch test for upper limb was conducted to know the flexibility in type II diabetes mellitus.

Population

20 Patients with age group 40 - 60 years in patients with type II diabetes mellitus.

Criteria for Sample Selection:

(a) Inclusion Criteria:

- Subject with type II Diabetes Mellitus.
- Age group 40 to 60 years (both males and females).
- HbA1c level between 6.5 to 9 are included.
- Sedentary lifestyle (not involved in sports activity, 6 months before the study).
- Willingness to participate. No visual perceptual, No communication problem.
- No serious uncontrolled medical problems.

(b) Exclusion Criteria:

- Any neurological deficits.
- HbA1c level between below 6.5 to above 9 are excluded. Age group below 40 to above 60 years (both males and females) are excluded.

- Recent musculoskeletal injury, current insulin therapy.
- Changes during previous 3 months in oral hypoglycaemic medication.
- Anti - hypertensive medication and lipid lowering medication were excluded.
- Patients were excluded if they took a - blockers, calcium channel blockers, or any other agent that influenced autonomic function.
- Un - cooperated patients serious sensory cognitive or aphasic deficit and severe cardiac problems.

Source of data

- Outpatient department - Nandha College of Physiotherapy, Erode.
- Oasis aquatic center, salem

Sample Size

Sample size is 20 patients.

- Group A - 10 patients.
- Group B - 10 patients.

Study Design

- Quasi Experimental design
- Pre and post experimental study design

Study Duration

Study was conducted for a period of 8 months.

Treatment Duration

Group A

- The aqua aerobic training sessions were 60 min in duration and consisted of 10 min warm - up, 40 min of aerobic training, and 10 min of cool down/stretching.
- Treatment was conducted for a period of 8 weeks, 3 sessions per week for 8 weeks.

Group B

- Proprioceptive neuromuscular facilitation (PNF) - 60 minutes per session. 5 days in week for 8 weeks.

Treatment Parameter

- The sit and reach test is the most common of all flexibility tests. It measures the flexibility of the patient lower back and hamstrings. The box about 30cm high and a meter ruler.
- The Back Scratch Test measures how close the hands can be brought together behind the back. The purpose to measure upper - body flexibility and the equipment is 18 inches ruler.

Procedure

- Patients was selected by convenient sampling method 20 patients who fulfilled inclusion criteria and exclusion criteria were selected by random sampling method, out of them 10 were allotted in group A and 10 were in group B.
- Patients were clearly explained about the study and written informed consent was Obtained from the Proper instructions such as purpose, safety, measures, comfort, precaution and psychological support were given to the patients.

- All vital signs were checked.
- While doing the assessment, Patients willingness to continue the procedure with or without rest was given reference Both group A and group B Patients were involved for pre test measurement.



Flutter Kicking

(A) Group A –Aqua Aerobic Exercise

Water offers a resistance and buoyancy that cannot be experienced when doing regular ground - based exercises. The benefits of water aerobics include lower blood pressure, increased bone density, stronger muscles, corrected body posture, pain relief, and weight loss. The calming effect of water on our bodies extends to our minds as well

The two essential advantages of water exercises are

- **More resistance:** Water is denser than air, which means it provides a greater resistance to movements.
- **Less pain and fatigue:** Water offers buoyancy that reduces the impact of exercises on your body.

Techniques and Application

The outline of aquatic aerobics exercise program

- Warm up exercises
- Water walking or jogging
- Arm curls
- Flutter kicking
- Forward and side lunges
- Back wall glide
- Jumping jacks
- High - knee lift extension
- One leg balance
- Hip kickers at pool wall
- Pool planks
- Arm raises
- Standing water Push ups
- Leg lifts
- Squats
- Cool down exercises.

For the following 8 weeks Aquatic aerobic exercise were done for 40 minutes duration. Each step is carried out by 10 - 20 repetitions into three sets with warming and cool down session. The prescribed exercise program consisted of various aquatic aerobic techniques. It was performed on the count.

patients who fulfilled the criteria. After completing the informed content and they were explained about the scale and the scale was administered.



Biceps Curl



Upper and Lower Limb Pattern (A) D1 Flexion (B) D1 Extension (C) D2 Flexion (D) D2 Extension

Group B: Proprioceptive Neuromuscular Facilitation

Procedure

- Proprioceptive neuromuscular facilitation stretching (hold and relax) in D1FLEXION, D2FLEXION, D1EXTENSION, D2EXTENSION pattern and major muscles stretching technique for upper and lower limb.
- These patterns were included in this study because they stretched all the major muscles of lower limb and upper limb.

Each pattern and technique method was held in stretched position for 30 sec and was repeated four times. A 15 sec relaxation period was given between each repetition and 30 sec relaxation period was given between different patterns and technique method.

3. Data Analysis and Results

Paired ‘t’ test was used for statistical analysis. Unpaired ‘t’ test has been used to find significance of the study parameters between groups. While paired ‘t’ test has been used to find significance of the study within the groups. This study results shows that there is statistically significant improvement in sit and reach test and back scratch test between pre and post – test mean values in group A and group B. Group A shows an improvement.

Sit and reach test	Group A	Group B
Pre - test mean	138	154
Post - test mean	212	198
Mean difference	7.4	4.4
Standard deviation	1.34	1.17
Paired ‘t’ test	17.34	11.85
Unpaired ‘t’ test	5.94	

Table 1: Paired ‘t’ test the values of sit and reach test in group A and B. The table 1 shows the analysis of sit and reach test in group A and B. The significance of the calculated ‘t’ value of sit and reach test is 17.34 and 11.85 in group A and B, which were greater than the tabulated ‘t’ value 2.262. **Unpaired ‘t’ test values** of sit and reach test in group A and group B. The table 1 shows the analysis of sit and reach test in group A and group B. The level of significance the calculated ‘t’ value is 5.94, which was greater than the tabulated ‘t’ value 2.09. The result shows that there is a marked difference between post - test values of group A and group B

Back scratch test	Group A	Group B
Pre - test mean	33	27
Post - test mean	12	15.7
Mean difference	2.1	1.13
Standard deviation	0.65	0.41
Paired ‘t’ test	10.8	8.69
Unpaired ‘t’ test	3.95	

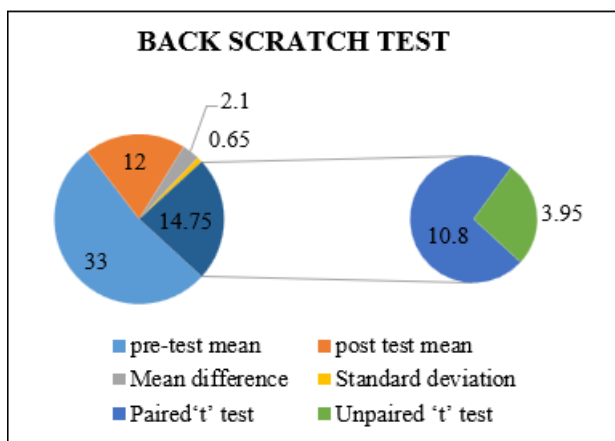
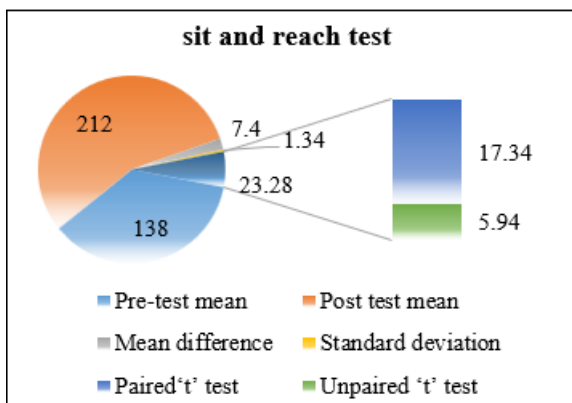


Table 2: Paired ‘t’ test the values of back scratch test in group A and B. The table 2 shows the analysis of back scratch test in group A and B. The significance of the calculated ‘t’ value of back scratch test is 10.08 and 8.69 in group A and B, which were greater than the tabulated ‘t’ value 2.262. **Unpaired ‘t’ test values** of back scratch test in group A and group B. The table 2 shows the analysis of back scratch test in group A and group B. The level of significance the calculated ‘t’ value is 3.95, which was greater than the tabulated ‘t’ value 2.09. The result shows that there is a marked difference between post - test values of group A and group B



3.1 Results

The study sample comprised **20 patients**, of which **10 were Group A** and **10 were Group B**. All the patients underwent general assessment performa. The median time interval between before and after therapy.

The pre test and post test values of group A and B were assessed by **sit and reach test** in 20 patients for type II diabetes mellitus. The **mean difference 7.4** and **4.4** respectively, the **standard deviation value is 1.34** and **1.17** respectively. The **paired 't' test value is 17.34** and **11.85** more than **table value of 2.262** respectively. The **unpaired 't' test value is 5.94** more than **table value of 1.725** and thus it denotes the significance.

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4. Discussion

The aim of this study was to compare the effectiveness of aqua aerobic exercise and proprioceptive neuromuscular facilitation (PNF) in improving upper and lower limb flexibility in patients with type II diabetes mellitus.

The study consisted of two groups: the aqua aerobic exercise group and the proprioceptive neuromuscular facilitation group. All participants were diagnosed with type II diabetes mellitus and had restricted upper and lower limb flexibility.

The participants in the aqua aerobic exercise group underwent an 8 - week aqua aerobic exercise program, while those in the proprioceptive neuromuscular facilitation group received an 8 - week proprioceptive neuromuscular facilitation program. Flexibility was measured using sit and reach test and back scratch test before and after the intervention period. The results were then compared between the two groups.

Aqua aerobic exercise, which is exercise performed in water, has several advantages for individuals with diabetes. The buoyancy of water reduces the impact stress on joints and muscles, making it a low - impact form of exercise. It also provides resistance to movements, allowing for strength training and endurance conditioning. Aqua aerobic exercises involve a wide range of movements that can help increase flexibility in the upper and lower limbs.

According to study **Nuttamonwarakul A, Amatyakul Set. al** Regular aqua - aerobic exercise training improved health - related physical fitness and glycemic control in T2DM patients. Therefore, aquatic exercise is a recommended treatment for elderly patients with type 2 diabetes. Of course it must be individually adjusted to the physiological and metabolic limitations of each patient.

Goran Sporis et al The study thirty five adults, age ranging from (39 to 73 years) aqua aerobic exercise reduces to some extent the multifactorial glycemc control, body weight and lipid profile with a relatively short intervention. Aqua aerobic exercise might be a good additional therapy for treatment of patients with type II diabetes mellitus.

On the other hand, According to study **Kayla B. Hindle et. al** proprioceptive neuromuscular facilitation stretching is a stretching technique involving alternating contractions and relaxations of muscles to improve flexibility. It is commonly used in rehabilitation settings and has shown positive results in improving range of motion and flexibility.

The findings of the study showed that both the aqua aerobic exercise group and the proprioceptive neuromuscular facilitation group exhibited significant improvements in upper and lower limb flexibility. However, these results suggest that aqua aerobic exercise is more effective than proprioceptive neuromuscular facilitation in improving upper and lower limb flexibility in patients with type II diabetes mellitus. The buoyancy and resistance provided by water during aqua aerobic exercise may contribute to the greater improvements observed in this group.

It is important to note that this study only focused on the effects of aqua aerobic exercise and proprioceptive neuromuscular facilitation on flexibility. Other aspects of physical fitness and overall health were not evaluated. Additionally, the study had a relatively small sample size, which may limit the generalizability of the findings.

Further research with larger sample sizes and longer intervention periods is needed to confirm and expand upon these results. Future studies could also explore the effects of combining aqua aerobic exercise with other interventions in improving flexibility and overall health in patients with type II diabetes mellitus.

5. Summary and Conclusion

Type II diabetes mellitus (T2DM) patients often experience decreased flexibility in their upper and lower limbs, which can result in reduced mobility and increased risk of falls. This study aimed to evaluate the effectiveness of aqua aerobic exercise and proprioceptive neuromuscular facilitation (PNF) in improving flexibility in type II diabetes mellitus patients.

A total of 20 T2DM patients were randomly assigned to two groups: aqua aerobic exercise group (n=10) and proprioceptive neuromuscular facilitation (PNF) group (n=10). The aqua aerobic exercise group participated in a 8 - week program of aerobic exercises performed in the water, while the proprioceptive neuromuscular facilitation (PNF) group received PNF stretching techniques targeting the upper and lower limbs. Flexibility was assessed before and after the intervention using sit and reach test for lower limb and back scratch test for upper limb.

The study showed that both the aqua aerobic exercise group and the proprioceptive neuromuscular facilitation group

exhibited significant improvements in upper and lower limb flexibility. While direct comparisons between aqua aerobic exercise and proprioceptive neuromuscular facilitation stretching in type II diabetes patients are lacking, both forms of exercise have their unique benefits. The aqua aerobic exercise group showed greater improvements compared to the proprioceptive neuromuscular facilitation group.

In conclusion, both aqua aerobic exercise and proprioceptive neuromuscular facilitation (PNF) are effective interventions for improving upper and lower limb flexibility in patients with type II diabetes. However, aqua aerobic exercise appears to be more effective than proprioceptive neuromuscular facilitation in this particular population.

It should be noted that further research is needed to explore the long - term effects and sustainability of these interventions, as well as their impact on other important outcomes such as glycemc control and cardiovascular health. Additionally, individualized exercise programs tailored to the specific needs and limitations of each patient should be considered to optimize the results.

6. Limitation

It is primarily related to the restricted timeframe. Our study had limitations such as a small sample size to make a clear comparison between groups. This problem resulted from the prolonged duration of the study design that was associated with difficult adherence to this long - term programme. The heterogeneity may indicate subgroups where aerobic exercise could be of clinical benefit in comparison with resistance exercise. In addition, we did not consider the psychological effect of attendance in the exercise activity.

7. Recommendation

A similar study may be extended with larger sample. Future study should focus on other parameters like High density lipoprotein cholesterol, Triglyceride (before and after intervention), biochemical tests. Future studies should focus on particular age of people. Long term follow up should be made to find out the effect of the treatment. Future long term studies focusing on patient - relevant outcomes are warranted.

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