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Effectiveness Of Aerobic Exercise And Stretching Exercise On Limited Joint Mobility Syndrome In Type II Diabetes Mellitus.

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Abstract
Background:
Limited Joint Mobility Syndrome (LJMS), a common yet under-recognized musculoskeletal complication of Type 2 Diabetes Mellitus (T2DM), leads to stiffness, pain, and restricted movement, particularly in the hands, shoulders, and lower limbs. Its pathogenesis is primarily driven by chronic hyperglycaemia, which promotes collagen glycation and connective tissue rigidity, negatively impacting functional capacity and quality of life.
Objective:
This study aimed to evaluate the effectiveness of aerobic and stretching exercises on joint mobility, pain reduction, and functional performance in individuals with T2DM diagnosed with LJMS.
Methods:
A total of 30 participants (aged 40–60) diagnosed with limited joint mobility syndrome in T2DM were included in this interventional study. A structured physiotherapy intervention program was implemented over 12 weeks, involving aerobic exercise (3 sessions per week, including walking, cycling, and low-impact aerobics) and stretching exercises (targeting hand, wrist, leg, and ankle joints). Outcome measures included the Visual Analogue Scale (VAS) for pain, Step Test to assess functional capacity, Goniometer for joint range of motion (ROM), Prayer Sign and Tabletop Sign to assess limited joint mobility syndrome. Data were analyzed using paired t-tests in Instat software.
Results:
There was a significant reduction in pain as measured by VAS, with the mean score decreasing from 5.6 to 3.33 ($p = 0.0001$). Step Test performance improved significantly, with test duration increasing from 2.30 to 2.91 minutes ($p < 0.0001$), step count rising from 44.5 to 68.57 ($p < 0.0001$), and heart rate decreasing from 128.53 bpm to 122.03 bpm ($p = 0.0276$). Goniometric assessments showed statistically significant improvements in joint flexion in the MCP joint ($p = 0.0322$), elbow joint ($p = 0.0065$), and ankle extension ($p = 0.0089$). Overall improvements were statistically and clinically significant.
Conclusion:
Aerobic and stretching exercises significantly improve joint mobility, reduce pain, and enhance functional capacity in T2DM patients with LJMS. These findings support incorporating structured physical activity programs into standard diabetes care to mitigate musculoskeletal complications and improve quality of life.
Keywords: *Type 2 Diabetes Mellitus, Limited Joint Mobility Syndrome, Aerobic Exercise, Stretching Exercise, Joint Range of Motion, Visual Analogue Scale.*

1. INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a long-term metabolic disease marked by elevated blood sugar levels brought on by insulin resistance and/or beta-cell malfunction. It is responsible for more than 90% of cases of diabetes worldwide and is linked to a number of chronic consequences, such as musculoskeletal abnormalities, macrovascular problems, and microvascular problems[1]. Despite having a significant impact on functionality and quality of life, musculoskeletal disorders are frequently overlooked among these complications2.

One of the most prevalent musculoskeletal complications among people with type 2 diabetes is Limited Joint Mobility Syndrome (LJMS), often referred to as diabetic cheiroarthropathy. Particularly in minor joints like the hands and shoulders, it manifests as stiffness and limited mobility*. According to estimates, between 8% to 58% of diabetics have LJMS, with a higher prevalence seen in those with inadequate glycaemic control[4].

LJMS has a multifactorial pathogenesis. One of the primary mechanisms is the development of advanced glycation end products (AGEs) as a result of chronic hyperglycaemia-induced non-enzymatic glycation of collagen. Due to the cross-linking of collagen fibres caused by these AGEs, connective tissue becomes less elastic and more rigid[5]. Additionally, in diabetic patients, microangiopathy and neuropathy worsen joint dysfunction[6].

Positive indicators such the "tabletop sign" or "prayer sign" and decreased range of motion (ROM) are clinical indicators of LJMS[7]. In addition to making daily tasks much more difficult, these restrictions can also raise the risk of secondary issues such diabetic foot pressure ulcers and fall-related injuries[8]. Therefore, in order to preserve joint function and avoid impairment, early management is crucial.

The key to managing diabetes has been identified as physical activity. Exercise offers substantial musculoskeletal advantages in addition to enhancing glucose metabolism[9]. Aerobic exercise in particular improves metabolic markers like HbA1c, lowers inflammation, and increases blood circulation[10]. Diabetes patients may experience an indirect improvement in joint health and mobility as a result of these systemic effects[11].

Because stretching exercises lengthen soft tissues, increase flexibility, and decrease contractures, they directly improve joint mobility[1]2. It has been demonstrated that routinely stretching the afflicted joints in diabetic patients improves range of motion and lessens functional impairments[1]*. Stretching can help counteract some of the structural stiffness brought on by collagen cross-linking and glycation when done regularly[14].

The benefits of combining aerobic and stretching workouts in the management of LJMS have been highlighted in a number of studies. Stretching focuses on the mechanical constraints of joints, whereas aerobic workouts improve cardiovascular and systemic effects. When used together, they can significantly enhance T2DM patients joint function, muscle performance, and general quality of life[15]. Standardized exercise regimens for LJMS in diabetics are still lacking, nevertheless, and many trials have small sample sizes or short study periods. To develop evidence-based exercise programs that may be widely used in clinical practice, more research is also required[16]. Examining the combined effects of aerobic and stretching workouts may offer important information about all-encompassing care plans for diabetic musculoskeletal problems[17].

Thus, the purpose of this study is to assess how well aerobic and stretching exercises affect joint mobility and glycaemic control in people with type 2 diabetes who have been diagnosed with LJMS. This study aims to improve functional results and quality of life for this expanding patient population by determining the best intervention modalities[18].

2. MATERIALS & METHODOLOGY

The Ethical Committee and Protocol Committee authorized the research investigation (protocol number -). The research is an interventional study involving 30 participants including both genders from the Karad, Maharashtra, India. This research recorded the pre- and post-treatment values between the same group that lasted for a duration of 6 months. The goal of this study was to find effectiveness of aerobic exercise and stretching exercise on limited joint mobility syndrome in type 2 diabetes mellitus. And to explore the experiences and perceptions of patients and health care providers regarding physiotherapy interventions.

This study was conducted as per inclusion and exclusion criteria. Participants were briefed on the study's nature, duration, and intervention in their language of choice. The subjects in this study were diagnosed with type 2 diabetes mellitus having limited joint mobility syndrome with age range:40-60 years. Patients had tested positive for table top test and prayer's sign. Patients with recent surgery or acute injuries and other medical conditions affecting joint mobility were excluded. This study was conducted on 30 patients. Informed consent was taken from the study participants & baseline data was collected. Pre-assessment was done regarding ROM, pain and functional capacity. They were assessed with Goniometer, Visual Analog Scale (VAS) and step test. The individuals taking part in the research were assigned to a group, who received a preset structured physiotherapy protocol for 3 times a week for 60 mins; for 12 weeks duration.

3. OUTCOME MEASURES

1. Visual Analog Scale (VAS)

It is a measurement tool that seeks to measure a characteristic that believed to range across a continuum of values and cannot easily be directly measured. VAS is a uni-dimensional measure of pain intensity, which has been extensively used in various adult people.

The Visual Analog Scale is typically a straight line that is 10 cm (or sometimes 100 mm) in length.

The scale has two endpoints, each representing the extremes of the experience being measured: Left Endpoint (0 or 0%): Represents the absence of the symptom or condition (for instance, "no pain" for pain assessments).

Right Endpoint (10 or 100%): Represents the worst possible level of the symptom or condition (e.g., "worst pain imaginable" for pain assessments).

2. Step Test – for Cardiovascular and Functional Endurance

The Step Test is a valuable, low-cost tool to evaluate cardiorespiratory endurance, which reflects how efficiently the heart and lungs supply oxygen during physical activity. improvements in Step Test outcomes (longer duration, higher step count, lower heart rate) indicate enhanced cardiovascular function, which may also contribute to improved peripheral circulation—benefiting joint mobility, tissue oxygenation, and overall musculoskeletal health in LJMS patients.

Assessment Method: Patient steps on and off a 12-inch platform for 3 minutes at a controlled pace. Heart rate is measured immediately post-exercise and during recovery. Functional modifications (e.g., 2-minute step-in-place) can be used if mobility is limited.

3. Prayer's Sign and Table Top Test – for Hand Function and Contracture

Purpose: Detects limited joint mobility (especially in hands/fingers), commonly seen in diabetic patients.

Assessment Method:

A. Prayer's Sign: Inability to press palms flat together indicates tightness.

B. Table Top Test: Inability to place palm flat on a table shows joint restriction.

4. Goniometer – to measure Range of Motion (ROM)

The goniometer is used to measure the range of motion (ROM) of affected joints to assess the extent of joint stiffness and restriction, common in Type 2 Diabetes Mellitus. To use the goniometer, the patient is positioned comfortably with the joint in a neutral or resting position. The goniometer's arms are aligned with the bones on either side of the joint, and the angle of movement is measured during flexion and extension. The goniometer provides an accurate degree of joint movement, allowing for the identification of limitations in flexibility.

Assessment Method:

A. Active joint angles are measured (e.g., Elbow, wrist, MCP, PIP, DIP, Ankle, MTP, PIP, DIP[Flexion/Extension]).

B. Measured before and after the intervention to assess improvement.

4. TREATMENT

Structured Protocol: 60 minutes of aerobic exercise 3 times a week and 10 minutes of daily stretching, for a duration of 12 weeks.

The 12-week intervention protocol was designed to progressively improve joint mobility and flexibility in individuals with Type II Diabetes Mellitus through a combination of aerobic and stretching exercises. The program was divided into weekly stages to allow gradual adaptation and ensure participant safety.

Weeks 1–2: Participants were introduced to the exercise routine with a focus on familiarization and technique. Aerobic sessions were conducted three times per week on alternate days, each lasting 60 minutes, including a 5-minute warm-up, 15 minutes of walking, 15 minutes of cycling, 5 minutes of low-impact aerobics movements, and a 5-minute cool-down. Intensity was maintained at a light-to-moderate level to allow physiological adaptation. Daily stretching sessions focused on basic hand, finger, and shoulder stretches, with each stretch held for 20 seconds and repeated twice.

Weeks 3–4: Aerobic activity was gradually intensified while maintaining frequency. Brisk walking and cycling durations were increased to 20 minutes each, and low-impact aerobics movements extended to 10 minutes. Participants were encouraged to slightly increase walking speed or cycling resistance to achieve a moderate intensity. Stretching routines were expanded to include leg and hip muscles, particularly hamstrings and quadriceps. Each stretch was held for 25–30 seconds, repeated two to three times daily or at least three times per week.

Weeks 5–6: Exercise consistency was emphasized. Aerobic sessions continued with the same structure and moderate intensity was maintained. Low-impact aerobics segments incorporated more fluid and rhythmic movements to challenge coordination and joint mobility without adding strain. Stretching routines became more dynamic with the inclusion of mild range-of-motion activities for wrists, shoulders, hips, and ankles. Flexibility improvements were monitored weekly.

Weeks 7–8: At this stage, aerobic sessions aimed at maintaining progress. Participants were encouraged to maintain pace or resistance during walking and cycling. Some were introduced to optional interval-style walking to challenge cardiovascular capacity while staying within safe limits. Stretching exercises became more individualized based on each participant's needs and areas of joint restriction, with increased focus on joint-specific stretches (e.g., wrist extension, shoulder abduction, hip flexor lengthening).

Weeks 9–10: Participants were encouraged to sustain their routine independently with periodic supervision. Aerobic sessions remained consistent, and participants who showed improved endurance were advised to moderately increase intensity (e.g., longer walking intervals or slightly higher cycling resistance). Stretching sessions focused on refining technique and maximizing range of motion, particularly in areas previously limited by stiffness.

Weeks 11–12: The final phase focused on consolidation and evaluation. Participants maintained the full aerobic protocol at moderate intensity and performed daily stretching exercises with maximum engagement. Emphasis was placed on fluid movement, posture, and joint alignment during both aerobic and stretching components. At the end of Week 12, post-intervention assessments were conducted to evaluate changes in joint range of motion, flexibility, and functional mobility.

5. RESULTS

For data analysis, the data was entered into an Excel spreadsheet, and statistical analysis was performed using the Instat app. Descriptive statistics were utilized, and paired t-tests were employed to ascertain significant differences between pre- and post-interventional group across (Goniometer, Step test, Visual analogue scale) outcome measures.

Table No.1: Comparison of Mean, SD, P Value & t value of VAS SCALE

VAS SCALE	Pre-test	Post-test	p-value	t-value
	5.6 ±1.090	3.33±0.9045	0.0001	20.185

Interpretation:

The VAS results show a significant improvement following the intervention, with the mean score decreasing from 5.6 (SD = 1.090) in the pre-test to 3.33 (SD = 0.9045) in the post-test. This reduction of 2.27 points is statistically significant (p = 0.0001), indicating that the intervention effectively reduced the condition being measured.

Table No. 2: Comparison of Mean, SD, P Value & t value of Step- test

STEP-TEST	Pre-test	Post-test	p-value	t-value

Test Duration	2.303±0.5543	2.906±0.1574	<0.0001	101.13
Step Count	44.5±11.485	68.566±3.559	<0.0001	105.52
HR	128.53±4.493	122.033±4.810	0.0276	138.96
Recovery HR	122.9±4.880	106.96±4.612	0.0846	127.02

Interpretation:
In the Step-Test, participants exhibited improved performance, with increased test duration (2.303 to 2.906 minutes) and step count (44.5 to 68.57), both highly significant ($p < 0.0001$). Additionally, post-test heart rate decreased from 128.53 to 122.03 bpm ($p = 0.0276$), suggesting improved cardiovascular efficiency.
Although recovery heart rate also improved, the change was not statistically significant. Overall, the intervention had a positive effect on both physical performance and symptom reduction.

Table No.3: Comparison of Mean, SD, P Value & t value of Prayer's sign and Table Top test

Outcome measure	Pre-test	Post-test	p-value	t-value
Prayer's Sign Score (0 = Normal, 1–2 = Impaired)	1.63 ± 0.49	0.73 ± 0.45	0.0001	9.10
Table Top Test Score (0 = Flat, 1–2 = Impaired)	1.57 ± 0.50	0.67 ± 0.48	0.0001	8.65

Interpretation:
The mean score reductions in both tests indicate improved hand mobility after the intervention.
Both Prayer's Sign and Table Top Test showed statistically significant improvement post-intervention ($p < 0.001$).

Table No. 4: Comparison of Mean, SD, P Value & t value of Goniometer assessment

JOINT	Post-test Flexion (Mean±SD)	Post-test Extension (Mean±SD)	P-Value (F)	P-Value (E)	T-Value (F)	T-Value (E)
MCP	77.33±7.884	28.23±3.866	0.0322	>0.10	53.724	40.003
PIP	70.16±8.371	0±0.000	>0.10	-	45.110	-
DIP	60.5±7.075	0±0.000	>0.10	-	46.839	-
Wrist	66.2±5.436	53.5±6.290	0.0549	>0.10	66.708	46.584
Elbow	130.23±9.526	0±0.000	0.0065	-	74.884	-
MTP	21.83±5.736	57.33±7.092	>0.10	>0.10	20.848	44.278

JOINT	Pre-test Flexion (Mean±SD)	Pre-test Extension (Mean±SD)	P-Value (F)	P-Value (E)	T-Value (F)	T-Value (E)
DIP	52±6.091	0±0.000	>0.10	-	46.758	-
PIP	29.3±4.496	0±0.000	>0.10	-	35.147	-
Ankle	40.1±6.076	14±2.051	>0.10	0.0089	36.147	37.386
MCP	72±7.830	22.8±3.699	0.0797	0.0470	50.365	33.760
PIP	65.3±9.293	0±0.000	>0.10	-	38.488	-
DIP	54.56±7.505	0±0.000	>0.10	-	39.824	-
Wrist	59.8±5.732	48.23±6.415	0.0957	>0.10	57.143	41.183
Elbow	114.96±12.173	0±0.000	0.0308	-	51.731	-
MTP	16.36±5.169	52.26±7.100	0.0514	>0.10	17.341	40.321
DIP	45.73±6.203	0±0.000	0.0666	-	40.382	-
PIP	24.4±4.673	0±0.000	0.0786	-	28.601	-
Ankle	34.53±5.710	7.6±1.868	>0.10	0.0221	33.126	22.283

Interpretation:
Following the intervention of aerobic and stretching exercises, there was a measurable improvement in joint range of motion, especially in flexion movements. Notably, MCP flexion improved significantly from 72° to 77.33° (p = 0.0322), and elbow flexion increased markedly from 114.96° to 130.23° (p = 0.0065), reflecting the effectiveness of the exercise program in enhancing mobility in larger upper limb joints.
Additionally, ankle extension showed significant progress, improving from 7.6° to 14° (p = 0.0089), suggesting a positive impact on lower limb function. Flexion in these joints showed moderate improvements (e.g., PIP flexion from 65.3° to 70.16).
Wrist flexion also improved from 59.8° to 66.2° with a p-value of 0.0549, indicating a trend toward significance. These results demonstrate that aerobic and stretching exercises are particularly effective in improving flexion and overall mobility in larger and moderately affected joints (e.g., PIP, DIP) may require longer duration or more intensive therapeutic strategies.
Overall, the intervention proved beneficial in reducing joint stiffness and enhancing functional capacity in patients with Type II Diabetes Mellitus suffering from Limited Joint Mobility Syndrome

6. DISCUSSION

The results of this study demonstrate that the combined intervention of aerobic and stretching exercises in improving joint range of motion (ROM) and alleviating symptoms in individuals with Type II Diabetes Mellitus (T2DM) and Limited Joint Mobility Syndrome (LJMS). The observed improvements in flexion movements, particularly in the MCP and elbow joints, align with previous research indicating that structured exercise programs can enhance joint mobility in diabetic populations. For instance, a study demonstrated that combined flexibility and resistance training led to significant improvements in joint ROM among older adults with T2DM, highlighting the effectiveness of such interventions in this demographic[19].
Additionally, the significant reduction in VAS scores from 5.6 to 3.33 (p = 0.0001) suggests a substantial decrease in pain perception, supporting the notion that the intervention not only improved mobility but also contributed to symptom relief. As stretching exercises led to a significant decrease in perceived pain and joint stiffness in diabetic individuals[20].
The Step-Test results further validate the effectiveness of the intervention, with significant increases in test duration and step count, along with a reduction in post-test heart rate, indicating enhanced cardiovascular efficiency and physical endurance. These improvements in physical performance states that aerobic exercises significantly improved functional capacity in diabetic populations[21].
Overall, the findings of this study suggest that aerobic and stretching exercises are an effective therapeutic approach for improving joint mobility, reducing pain, and enhancing functional capacity in individuals with LJMS associated with Type II Diabetes Mellitus.

7. CONCLUSION

This study demonstrates that aerobic and stretching exercises are effective interventions for improving joint mobility, reducing pain, and enhancing functional capacity in individuals with Type II Diabetes Mellitus (T2DM) suffering from Limited Joint Mobility Syndrome (LJMS). The significant improvements in joint range of motion, especially in flexion movements such as MCP and elbow flexion, along with the notable reduction in VAS scores, underscore the positive impact of these exercise interventions on mobility and symptom management. Additionally, the results from the Step-Test highlight improvements in cardiovascular efficiency and physical endurance, suggesting that the combination of aerobic and stretching exercises offers both musculoskeletal and cardiovascular benefits. Overall, this study supports the integration of these exercises into therapeutic programs for managing LJMS in individuals with T2DM, promoting better joint health, reducing pain, and improving overall quality of life. Future research should focus on optimizing the intensity, duration, and frequency of these interventions to maximize their effectiveness and explore their long-term benefits for diabetic patients.

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