Effect Of Respiratory Muscle Stretch Gymnastics On PEFR And Exercise Capacity In Subjects With Type 2 Diabetes Mellitus – Experimental Study

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Abstract: Background: Diabetes is a chronic illness that develops when blood glucose levels stay higher than normal. According to WHO, over 90% of individuals with diabetes around the world have Type 2 diabetes. The prevalence of type 2 diabetes among 20-79 age group was 74.2 million in 2021 and will be 124.9 million in 2045. Globally India ranks 2nd with subjects with type 2 diabetes mellitus. Diabetics patients are more likely to experience heart failure or respiratory infections, both of which can leads to a reduction in lung functions. Studies have shown significant decrease in PEFR in diabetic subjects. This could be linked to weak mechanical qualities of the lungs, such as lung compliance and elastic recoil. Diabetes is one of several illnesses that limit regular physical capacity. The decline in exercise ability in persons with DM may be connected to poor glucose metabolism. Several studies have found that diabetes mellitus is connected with decreased lung function and respiratory muscle weakness, and this relationship could be regarded as evidence of diabetes's harmful effects on the lung. RMSG is designed to decrease chest wall stiffness, particularly in the chest wall respiratory muscles.

Purpose: To study the effects of respiratory muscle stretch gymnastics on PEFR and Exercise capacity in subjects with type II diabetes mellitus.

Methodology: Participants were briefed about the nature of the study and the intervention. Their informed written consent was taken. 45 participants were selected based on the selection criteria. Prior and after the treatment the outcome measures that is PEFR and Exercise capacity were taken. Intervention protocol was given for twice a day, four times each of five patterns for 4 weeks.

Results: The p-value after paired sample t tests in both groups is less than 0.05 which indicates the strong evidence that there is a significant difference between the pre-test and post-test scores of PEFR and Exercise capacity after RMSG training.

Conclusion: The present study concluded that there is significant improvement in PEFR and exercise capacity in type II DM patients after RMSG.

Key words: Type 2 Diabetes mellitus, Peak expiratory flow rate, Exercise capacity, Respiratory muscle stretch gymnastics.

I. INTRODUCTION

Diabetes is a chronic illness that develops when blood glucose levels stay higher than normal.[1] This occurs when either insufficient insulin is produced by the pancreas or when the body is unable to utilize the insulin that is produced. Insufficient insulin synthesis causes type I diabetes, but inefficient insulin utilization by the body leads to type II diabetes.[1] According to IDF diabetes atlas 2021, the prevalence of type 2 diabetes among 20-79 age group was 74.2 million in 2021 and will be 124.9 million in 2045. Globally India ranks 2nd with subjects with type 2 diabetes mellitus.[2]

Risk factors for Type 2 diabetes are overweight/obesity, family history of diabetes, tobacco use, excess alcohol intake, prior history of gestational diabetes, impaired glucose tolerance and physical inactivity.[1] Diabetes raises the risk of stroke and heart diseases. A prominent cause of blindness is diabetes retinopathy, which is brought on by cumulative long-term damage to the retina's small blood vessels. Foot ulcers and ultimately limb amputation is more likely in individual with diabetic neuropathy. One of the main factors contributing to kidney failure is diabetes.[1] This needs to be managed and cared for throughout life. Additionally, oral medicines, insulin or both are required to manage blood glucose level.[1]

Diabetes mellitus is a major public health problem with an increasing incidence globally and long-term consequences of several organs, including the lungs.[27] Impaired respiratory function may lead to the development of pulmonary complications.[7] Some significant alteration in DM includes decreased lung volume, impaired respiratory muscle function, decreased elastic recoil, chronic low-grade inflammation a decreased in the lungs ability to diffuse carbon monoxide and autonomic neuropathy affecting the respiratory muscles.[8] Studies have shown significant decrease in PEFR in diabetic subjects. This could be linked to weak mechanical qualities of the lungs, such as lung compliance and elastic recoil. Furthermore, myopathic or neuropathic abnormalities as well as alteration in bronchial reactivity, influences the respiratory muscles, reducing the endurance and efficiency of the ventilatory pump.[7] DM has also been linked to thicker alveolar and capillary walls as well as pulmonary arteriolar walls. The elastic nature of the lung supports the intrathoracic airways and help to preserve their patency. As a result, diabetic people are more likely to develop persistent airflow restriction.[4] The thorax and lung have a high collagen and elastin content. Non enzymatic glycosylation of these structural components can cause thoracic and lung parenchymal stiffness. This may lead to restrictive pattern.[8] Also, there was decrease in PEFR in all trimesters of pregnancy. The progressive decreased in PEFR values during the three trimesters of pregnancy can be linked to the mechanical impact of a larger gravid uterus reducing vertical dimension by limiting diaphragm movement.[9] PEFR is also reduced in obese this may be due to the fat buildup between the muscles and the ribcage increases the metabolic demands and effort load associated with breathing.[10]

Diabetes is one of several illnesses that limit regular physical capacity. Impaired exercise capacity is a strong and independent predictor of a higher risk of cardiac events in diabetic patients. The decline in exercise ability in persons with DM may be connected to poor glucose metabolism. Hyperglycemia enhances protein glycation and the production of advanced glycation end products. In this case, there is evidence linking poor glycemic management to heightened vessel stiffness in the vascular bed of multiple organs, including lungs.[11] Glycosylation may disrupt the function of a variety of proteins, and vascular or endothelial dysfunction may be a link between decreased exercise capacity and the metabolic abnormalities associated with poor diabetes control.[12] Several studies have found that diabetes mellitus is connected with decreased lung function and respiratory muscle weakness, and this relationship could be regarded as evidence of diabetes's harmful effects on the lung.[6] In the rehabilitation of patients with chronic obstructive pulmonary disease (COPD), respiratory muscle stretch gymnastics (RSMG) has been recommended. This technique aims to stretch the inspiratory chest wall muscles during inspiration and expiratory chest wall muscles during expiration. [22]

Muscle spindles are stimulated by stretching, and during contraction, their sensitivity is enhanced by alpha-gamma coupling. Thus, stretching the contracting muscle provides a significant stimulation to the muscle spindles. Kanamaru et al. measured electromyographic activity in respiratory muscles and discovered that it is higher during RMSG than during deep breathing alone, indicating that RMSG stimulates muscle spindles. This increased the force exerted by the muscles during respiration, resulting in an improvement in PEFR.[14] Patients with respiratory disorders may find respiratory muscle stretch gymnastics (RMSG) to be a beneficial adjunctive form of rehabilitation.[16] It is a simultaneous stretching and breathing technique that has been shown to help individuals with chronic obstructive pulmonary disease (COPD) by enhancing the function of their respiratory muscles.[15] Hagbarth et al. reported RMSG which, was intended to lengthening the respiratory muscles, enhancing chest wall compliance and decreased chest wall stiffness, improving pulmonary function and chest expansion.[16] RMSG is designed to decrease chest wall stiffness, particularly in the chest wall respiratory muscles.[16] Previous studies gave positive results on effect of respiratory muscle stretch gymnastics on PEFR and chest expansion in sawmill workers.[16] Also, PEFR and exercise capacity in elderly and CABG patients.[14] [17] [18]

MATERIALS AND METHODOLOGY

1. Pocket peak flow meter.
2. Two cones.
3. Stopwatch
4. Pulse oximeter
5. Chair
6. Sphygmomanometer
7. Weight machine
8. Height measurement scale

METHODOLOGY

1. Study type: Experimental study
2. Study design: Randomized clinical trial
3. Study duration: 6 months
4. Type of sampling: Simple random sampling
5. Sample size: 45
6. Study setting: Tertiary care hospital, Sangli district.

OUTCOME MEASURES

1. Peak expiratory flow rate:

- A peak flow meter is a portable, inexpensive, hand-held device that measures your ability to push air out of your lungs.
- PEFR is measured in sitting position with standard pocket peak flow meter. The subject were instructed to take maximum inspiration and blow into mouthpiece as rapidly, forcefully and completely as possible.
- They were instructed to maintain a tight sealing between lips and mouthpiece of the peak flow meter.
- It has been accepted that readings from these portable PEF meters are sufficiently accurate and repeatable for clinical purpose. The PFM has sensitivity of 94.5%. [20]

2. Exercise capacity:

- The 6 min walk test is a useful measure of functional capacity. The 6MWT was conducted according to the American Thoracic Society (ATS) guidelines.
- The 6MWT have been proven to be the most practical examination to perform, especially in the cardiopulmonary field throughout wide age group.
- Participants were asked to walk a distance of 30 m back and forth for 6min and the distance covered was documented.
- Validity is 0.998 and Reliability is 0.999 [26]

Respiratory Muscle Stretch Gymnastics Training Program

- Pattern 1: Patients were instructed to elevate and pull their shoulders back. Elevate and pull back both shoulders as you slowly breathe in through your nose. After taking a deep breath, slowly exhale through your mouth while relaxing and lowering your shoulders.

- Pattern 2: Upper chest stretching uncross your hands on your chest. Pull your elbows back and down slowly while lifting your chin and taking a deep breath through your nose. Relax and exhale slowly through your mouth.

- Pattern 3: Back muscle stretching keeps your hands clasped in front of your chest. As you slowly inhale through your nose, stretch your back by moving your hands forward and down. After a deep inspiration, slowly exhale and return to the original position.

- Pattern 4: Lower chest stretching grasp the ends of a face towel at shoulder heights with both hands outstretched. After taking a deep breath, raise your arms and slowly exhale. Lower your hands and breath normally after a deep exhalation.

- Pattern 5: Elbow elevation one hand should be held behind your head. Breathe deeply through your nose. Stretch your trunk by raising your elbow while slowly exhaling through your mouth.

- Treatment protocol**:** Four times each of five patterns, twice a day for four weeks.

RESULTS

Statistical analysis was done using paired sample t test.

Table no. 1: Normality test using Shapiro-Wilk

Variable	Time Frame	z-value	p-value
PEFR	Pre	0.908	0.050
	Post	0.935	0.052
Exercise Capacity	Pre	0.974	0.466
	Post	0.962	0.195

Table no. 2: Shows descriptive statistics of frequency of both genders

Gender	Frequency	Percent
Male	23	51
Female	22	49
Total	**45**	**100**

Graph no. 1: Shows gender distribution among experimental group

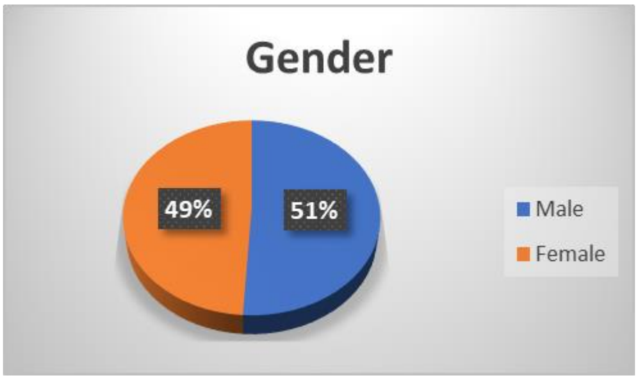


Table no. 3: Shows descriptive statistics according to age

	Gender	Mean	SD	t-value	p-value
Age	Male	53.00	6.65	0.395	0.695
	Female	52.09	8.70		

Graph no. 2: Represent age distribution among experimental group.

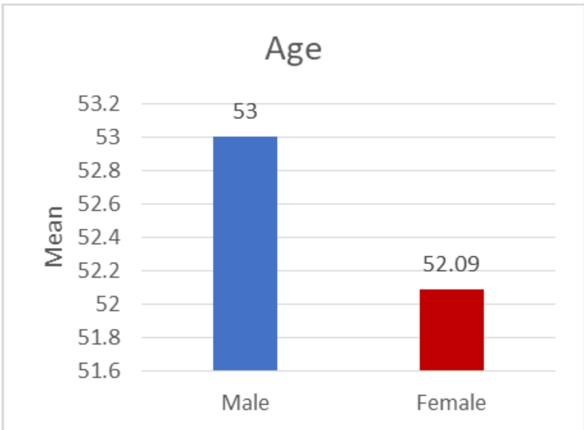


Table no. 4: Shows descriptive statistics of frequency of duration of diabetes.

Duration of Diabetes	Frequency	Percent
4.1 Years	1	2.22
4.6 Years	1	2.22
4.10 Years	1	2.22
4.11 Years	1	2.22
4.12 Years	3	6.67
5 Years	3	6.67
5.2 Years	1	2.22
5.4 Years	1	2.22
5.6 Years	1	2.22
5.9 Years	1	2.22
6 Years	5	11.11
6.1 Years	3	6.67
6.11 Years	1	2.22
7 Years	4	8.89
7.6 Years	1	2.22
7.10 Years	1	2.22
8 Years	1	2.22
8.5 Years	2	4.44
9.2 Years	1	2.22
9.6 Years	1	2.22
10 Years	5	11.11
10.4 Years	1	2.22
10.9 Years	1	2.22
12 Years	3	6.67
15 Years	1	2.22
Total	45	100

Graph no. 3: Shows frequency of duration of diabetes.

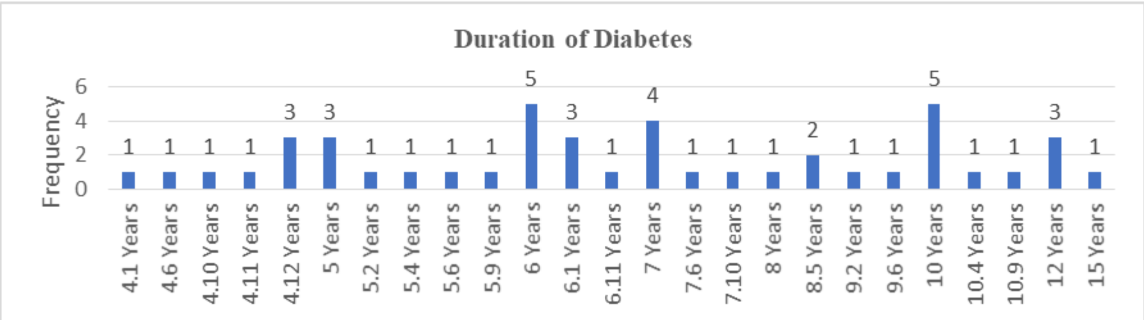


Table no. 5: Comparison of pre-test and post-test scores of PEFR by paired sample t test.

Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	t-value	p-value
Pre	362.27	65.25	93.29	22.98	4.06	27.234	0.001*
Post	455.56	60.72					

Above table indicates there is a significant statistical reliable difference between the pre & post treatment values with p-value is less than the 5% significance level (i.e. 0.001 < 0.05) in the study and therefore it justifies the improvements in health outcome post intervention.

Graph no. 4: Shows comparison of pre-test and post-test of PEFR.

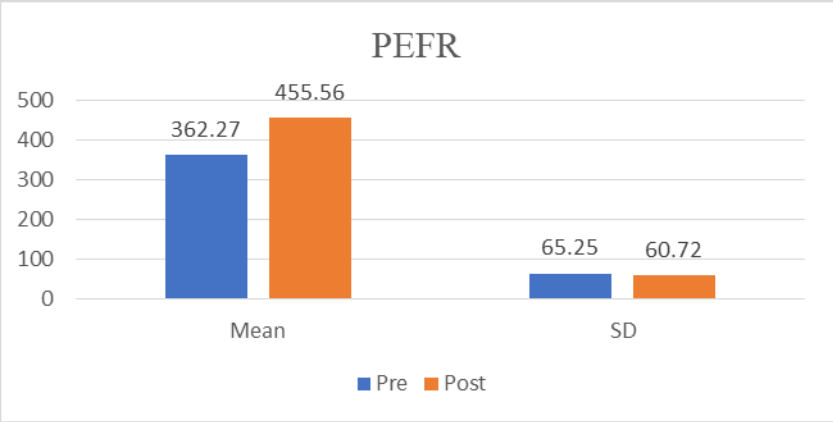


Table no. 6: Comparison of pre-test and post-test scores of Exercise Capacity by paired sample t test.

Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	t-value	p-value
Pre	5 26.47	6 8.79	27.52	2 0.16	1.37	9.159	0.001*
Post	5 53.99	6 2.90					

Above table indicates there is a significant statistical reliable difference between the pre & post treatment values with p-value is less than the 5% significance level (i.e. 0.001 < 0.05) in the study and therefore it justifies the improvements in health outcome post intervention.

Graph no. 5: Shows comparison of pre-test and post-test of Exercise Capacity.

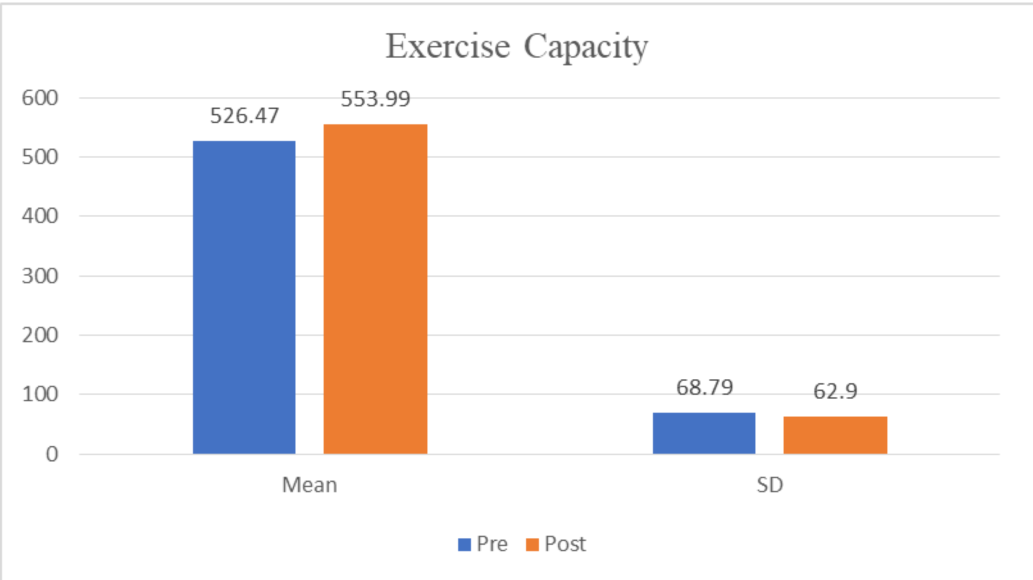


Table no. 7: Comparison of pre-test and post-test scores of PEFR in two groups paired sample t test.

Above table indicates there is a significant statistical reliable difference between the pre & post treatment values of

Groups	Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	t-value	p-value
Controlled diabetes	Pre	333.92	58.57	108.08	16.16	6.69	24.109	0.001*
	Post	442.00	53.48					
Uncontrolled diabetes	Pre	378.59	59.66	86.89	23.32	3.73	19.362	0.001*
	Post	465.48	58.57					

controlled and uncontrolled diabetes with p-value is less than the 5% significance level (i.e. 0.001 < 0.05) in the study and therefore it justifies the improvements in health outcome post intervention.

Graph no. 6: Comparison of pre-test and post-test of PEFR in controlled and uncontrolled diabetes.

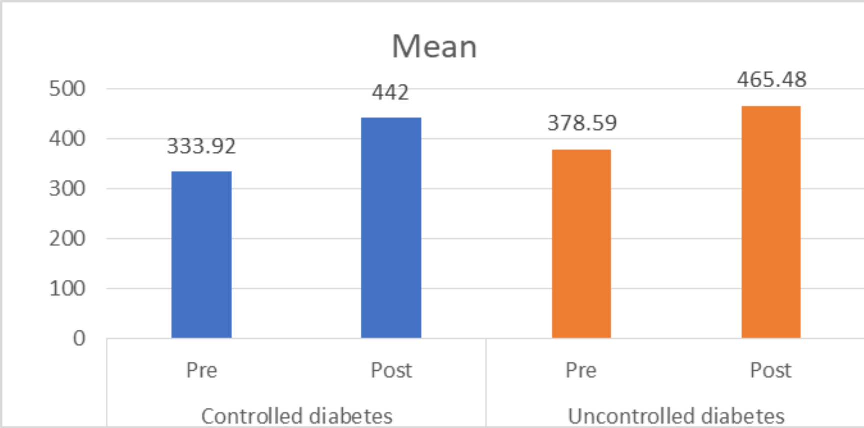
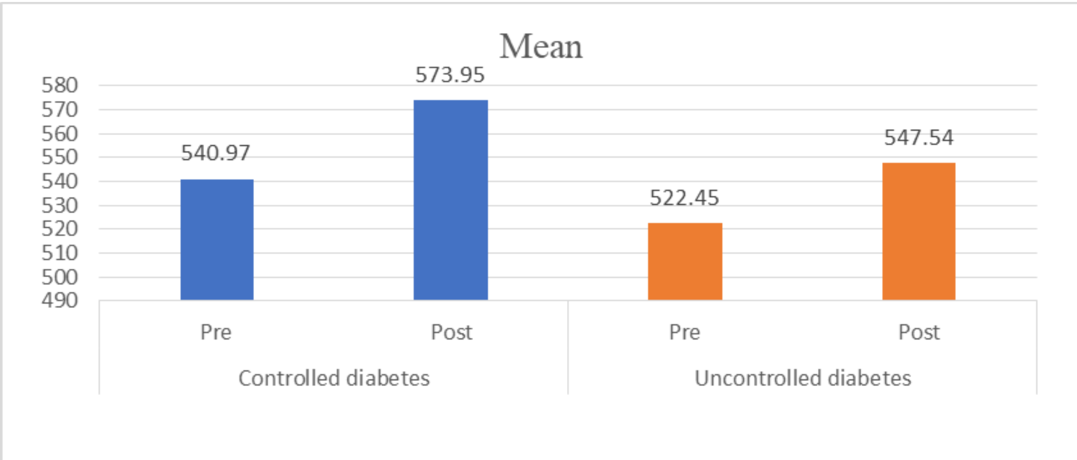


Table no. 8: Comparison of pre-test and post-test scores of Exercise Capacity in two groups by paired sample

Groups	Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	t-value	p-value
Controlled diabetes	Pre	540.97	77.74	32.98	23.47	1.41	5.067	0.001*
	Post	573.95	69.75					
Uncontrolled diabetes	Pre	522.45	63.36	25.09	18.83	1.33	6.921	0.001*
	Post	547.54	58.57					

Above table indicates there is a significant statistical reliable difference between the pre & post treatment values of controlled and uncontrolled diabetes with p-value is less than the 5% significance level (i.e. 0.001 < 0.05) in the study and therefore it justifies the improvements in health outcome post intervention.

Graph no. 7: Comparison of pre & post-test of exercise capacity in controlled and uncontrolled diabetes.



Graph no. 8: Comparison of mean values of pre and post-test of PEFR and exercise capacity in controlled and uncontrolled diabetes.

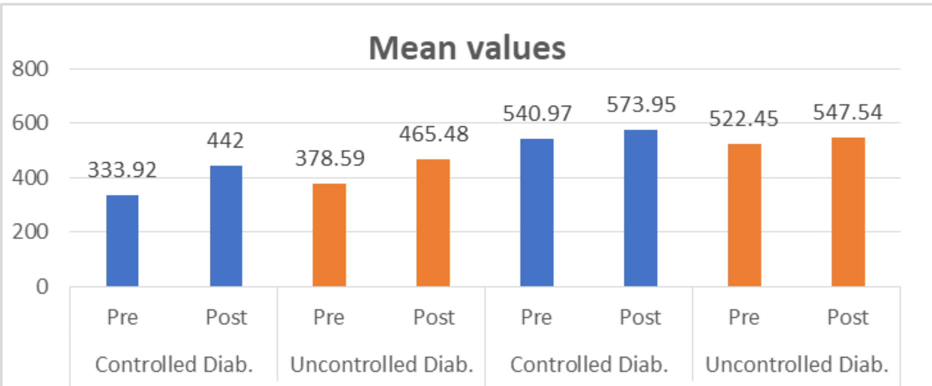


Table no. 9: Comparison of controlled and uncontrolled diabetes based on effect size

Variable	Effect size of PEFR	Effect size of Exercise capacity	Remarks
Controlled diabetes	6.69	1.41	Controlled diabetes is better
Uncontrolled diabetes	3.73	1.33	Controlled diabetes is better

Above table indicates higher the effect size greater would be the improvements in the health issues. Thus, for the present study Controlled diabetes has shown higher effect size indicating better improvements than Uncontrolled diabetes.

Results from analysis:

The final analysis proves that RMSG training is clinically significant in case of PEFR and Exercise capacity in type II DM. Paired t test is used to analyze the effect of RMSG on PEFR and Exercise capacity in type II DM which shows that there was significant increase in PEFR [p-value i.e. 0.001<0.05] and Exercise capacity [p-value i.e. 0.001<0.05]
The mean value of PEFR indicated changes in post treatment and higher values are recorded for post treatment outcome and also the standard deviation shows the consistency with post treatment value which is less than pre value. The effect size or Cohen's D indicates 4.06 value which is assumed to be very high in effect size as per the standard parameters of reference. Also, the mean value of Exercise capacity indicated changes in post treatment and higher values are recorded for post treatment outcome and also the standard deviation shows the consistency with post treatment value which is less than pre value. The effect size or Cohen's D indicates 1.37 value which is assumed to be high in effect size as per the standard parameters of reference.
The mean value in controlled diabetes group indicated changes post treatment and higher values are recorded for post treatment outcome and also the standard deviation shows the consistency with post treatment value which is less than pre value. The effect size or Cohen's D indicates 1.41 value which is assumed to be very high in effect size as per the standard parameters of reference.
The mean value in uncontrolled diabetes group indicated changes post treatment and higher values are recorded for post treatment outcome and also the standard deviation shows the consistency with post treatment value which is less than pre value. The effect size or Cohen's D indicates 1.33 value which is assumed to be very high in effect size as per the standard parameters of reference.

DISCUSSION:

Diabetes is a chronic illness that develops when blood glucose levels stay higher than normal.[1] Diabetes mellitus is a major public health problem with an increasing incidence globally and long-term consequences of several organs, including the lungs. [30] Various studies have shown significant decrease in PEFR and exercise capacity in subjects with type II DM. [5] [11]

The sample size of this study is 45. Both males and females were included within 20-60 age group. According to IDF Diabetes Atlas 2021, the prevalence of type 2 DM among 20-70 age group was 74.2 million. The estimated prevalence of type II DM in women aged 20-79 years is slightly lower than in men (10.2% vs 10.8%). In 2021, there are 17.7 million more men than women living with diabetes.[2] In the present study, 23 males and 22 females were participated in this research program with willing consent taken from them. Study have proved that men have larger amount of visceral (mostly abdominal fat) than women. Women generally have more subcutaneous fat (mostly leg and hip fat) than visceral fat. Visceral fat is more metabolically active than subcutaneous fat, which means that the fat creates hormones that can affect a person's overall health. Visceral fat accumulation is highly associated with an increased risk of metabolic syndrome, which includes type II diabetes.[24] Subjects with duration of DM above 5 years were included in this study. N. mageswaram et al found PEFR is significantly reduced in diabetics compared to non-diabetics and there is strong association exists between duration of diabetes and PEFR, i.e. as duration of DM is more PEFR is less.[5] Sangita Phatale et. al. shown that PEFR is reduced in DM patients with duration above 5 years. PEFR was lower in patients with longer durations than in patients with shorter durations.[25] In the present study, subjects with duration of type II DM ranges between 5-10 years is more.
There was an improvement in PEFR of subjects post intervention which was highly significant statistically (p-value i.e. 0.001 < 0.05) with effect size 4.06. Peak Expiratory Flow Rate (PEFR) is the maximum flow that may be produced during forced expiration following maximal inhalation. It assesses the ease with which the lungs withstand resistance in the major airways, as well as the strength of the expiratory muscles. The PEFR can be measured using a wright's

peak flow meter. It is one of the simple methods of monitoring serial changes in airway obstruction over a period of time.[5] It is an important parameter of pulmonary functions tests. Evidence supports the involvement of lungs in subjects with diabetes mellitus. Diabetes mellitus has been linked to thickened alveolar walls, alveolar capillary walls, and pulmonary arteriolar walls. Collagen and elastic alterations have also been linked to diabetes mellitus. The elastic nature of the lung supports the intrathoracic airways and helps to preserve their patency. [4] Anandhalaskshmi et al shown that reduced in PEFR in DM patients may be related with the poor mechanical properties of the lung, like lung compliance and elastic recoil of lungs.[7] Respiratory muscle stretching may therefore have a similar effect on chest wall compliance and a reduction in chest wall stiffness. It may also produce a strong stimulus for the respiratory muscle spindles, which would increase the respiratory apparatus's efficiency and account for the increased PEFR post RMSG training.

There was an increase in 6MWT distance post intervention which was statistically significant (p-value i.e. 0.001< 0.05) with effect size 1.37 suggesting that there was an improvement in subject exercise capacity after RMSG. Walking tests are useful for assessing a patient's junctional exercise capacity, which is the ability to perform physically demanding tasks that are part of daily living.[14] Hisayo yokoyama et al shown thatSedentary lifestyle and decreased cardiorespiratory fitness are major predictors of cardiovascular and all-cause mortality in a healthy population, and the same is true for people with type 2 DM.[13] Impaired exercise capacity is a strong and independent predictor of an increased risk of a cardiac incident in DM patients. The decline in exercise capacity in diabetic patients may be connected to poor glucose metabolism. Hyperglycemia increases protein glycation and the production of advanced glycation end products. In this circumstance, poor glycemic control has been related with increased stiffness of arteries in the vascular bed in various organs, including the lungs.[11] The effect size of RSMG training in type II DM is comparatively less as it is directly related to increase blood glucose levels. A combination of aerobic and resistance training maybe more effective for BG management than either type of exercise alone. [28] [29]

In this study, comparison of PEFR and exercise capacity in controlled and uncontrolled type II diabetes has shown significant statistical difference. In both of the groups PEFR and exercise capacity is improved. There was an improvement in PEFR in controlled type II DM (p value 0.001<0.05) with effect size 6.69 and exercise capacity (p value 0.001<0.05) with effect size 1.41. Also, in uncontrolled type II DM there was an improvement in PEFR (p value 0.001<0.05) with effect size 3.73 and exercise capacity (p value 0.001<0.05) with effect size 1.33. Therefore, in the present study there is more improvement in PEFR and exercise capacity in controlled type II DM than uncontrolled type II DM. This is maybe because of controlled glucose levels as compare to uncontrolled glucose levels.

To enhance the lung's respiratory capabilities, a variety of exercises, mobilizations, and respiratory muscle training methods have been used. Respiratory muscle stretch gymnastics (RMSG) is one such technique. Stretching and breathing exercises are typically administered individually, but with RMSG, they are combined together. Thus, RMSG is a developing approach for respiratory muscle conditioning. RMSG is a set of stretching exercises performed successively to stretch specific muscles involved in respiration. It stretches the inspiratory intercostal muscles during inspiration and the expiratory intercostal muscles during expiration, which aims to reduce chest wall stiffness.[14] Mistry Hetal et al. studied RMSG in elderly and its impact on maximum breathing capacity, PEFR, and exercise capacity. The study results suggested that RMSG leads to an improvement in their maximum breathing capacity, PEFR, exercise capacity, rate of perceived exertion and posture.[14] Hideko mineguchi et al reported a significance improvement in 6 MWT and reduction of functional residual capacity (FRC) in patients with COPD after RMSG training. [23] Minoru ito el al investigated immediate effect of RMSG and diaphragmatic breathing on the respiratory pattern in patients with COPD there results suggest that RMSG may have a beneficial effect on respiratory patterns. [22] In our study also we found an improvement in PEFR and exercise capacity in type II diabetes subjects.

CONCLUSION

This study concluded that respiratory muscle stretch gymnastics has a significant effect on increasing PEFR and improving Exercise capacity in subjects with type II diabetes mellitus.

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