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Effect of Inspiratory Muscle Training on Functional Capacity, Glucose Control and Heart Rate Recovery in Physically Inactive Diabetic Patients."

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KEYWORDS

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ABSTRACT:

Diabetes mellitus (DM) has become a rising epidemic in the past few years, surging in the last few decades with the rise of obesity, and has become one of the leading causes of death worldwide Respiratory system dysfunction, among other multisystem dysfunctions, are linked to (T2DM). They exhibit lower lung volumes, impaired exercise capacity, and central and peripheral muscular weakness. However, the inspiratory muscle is rarely assessed in routine clinical practice, which could lead to respiratory symptoms associated with inspiratory muscle weakening being unnoticed. A total number of 43 people with type 2 DM participated in this study. Assessment was done before beginning Inspiratory muscle training and after 8 weeks of intervention. There was significant improvement in functional capacity ($p < 0.001$), heart rate recovery of patient($p<0.001$) after 8 weeks of Inspiratory Muscle Training. Blood glucose levels (Hba1c) did not show significant difference when compared with other parameters (p-0.0077). The study concludes that Inspiratory muscle training improves functional capacity and heart rate recovery in Type II diabetes mellitus patients.

Introduction-

In 2017, around 451 million people worldwide were affected by diabetes mellitus. Projections suggest this number will increase to 693 million by 2045**.1** T2DM can lead to serious cardiovascular complications such as coronary heart disease, cardiomyopathy, arrhythmias, sudden death, cerebrovascular disease, and peripheral artery disease. Cardiovascular disease is the top cause of death in people with diabetes. Studies have shown a connection between T2DM and vascular problems, especially when combined with risk factors like hypertension, obesity, and dyslipidemia.2 The impact of DM on lung function and respiratory muscles is debated in literature. Some studies show that individuals with T2DM have lower lung function compared to healthy individuals. The severity and duration of diabetes, along with high blood glucose levels, are inversely related to lung function.3 Patients with T2DM experienced enhanced exercise capacity and increased diaphragm strength as a result of engaging in incremental inspiratory muscle training.4 Compared to non-diabetic individuals, T2DM patients often have muscle weakness, reduced lung volumes, and exercise capacity.5,6

The importance of assessing the inspiratory muscle in routine clinical evaluations is often overlooked, leading to potential undiagnosed respiratory issues related to weak inspiratory muscles. Identifying this problem promptly and implementing an appropriate treatment plan can help prevent future complications. However, there is limited research in this field, with only two studies investigating the impact of inspiratory muscle training (IMT) on patients with T2DM and inspiratory muscle weakness.7,8 Impaired functional capacity is a key indicator of mortality and morbidity in individuals with type 2 diabetes. Research studies have shown diminished functional capacity in DM2 patients compared to healthy individuals.9Autonomic neuropathy is often associated with a reduced heart rate response during exercise, which, when combined with diabetes, can predict mortality. However, the effects of diabetes on

Journal of Chemical Health Risks

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exercise heart rate and the role of impaired heart rate in mortality among diabetic patients have not been fully explored.10Heart rate variability, which assesses the impact of sympathetic and parasympathetic influences on the heart, experiences a decrease when autonomic dysfunction associated with hyperglycemia is present.11. We aimed to find the effect of inspiratory muscle training on functional capacity, blood glucose levels and heart rate recovery in physically inactive diabetic patients.

Materials and Methods

Study design and study subjects

Research design of the study was pretest and post-test experimental study. This research was carried out from February 2023 to January 2024 after being approved and ethical clearance was obtained from Institutional Research and Ethics Committee. The sample of this study amounted to 43 people with type 2 Diabetes Mellitus. Among them 17 were males and 26 were females.

Inclusion Criteria

Both male and female between age group of 30-60 years old who are diagnosed with Type 2 Diabetes mellitus by physician. Also, Participants with fasting blood glucose level >126mg/dl and random blood glucose level >200mg/dl. Participants who are physically inactive (not participating low to moderate intensity exercises for at least 30min, 5days/week)

Exclusion criteria:

This study did not include Participants with obesity (BMI more than 29.9 kg/$m^{2)}$ Participants with known case of cardiac disease or pulmonary condition. Participants who complained of dyspnea (grade 3- 4 of dyspnea according to Modified medical research Centre)

Outcome Measures

1) 6-minute walk test

6-minute walk test was conducted as per ATS guidelines and has a good test-retest reliability (r=0.94) and validity (r=0.82). 6MWT is a widely used tool for measuring functional capacity, known for its simplicity, cost-effectiveness, and ability to assess endurance during physical activity. It is also valuable for evaluating treatment effectiveness and overall cardiovascular and respiratory function.

- Formula for calculating predicted 6 – Minute Walk distance for men, 6MWD = (7.57 x height in cm) - (5.02 x age) - (1.76 x weight in kg) - 309 m,
- Formula for calculating predicted 6 – Minute Walk distance for women, 6MWD = (2.11 x height in cm) - (2.29 x weight in kg) - (5.78 x age) + 667 m.

2) 3 minute step test

Heart rate recovery is the difference between the heart rate at the end exercise (assumed to be the peak heart rate) and heart rate after 1 minute of stopping the exercise and has a validity of r = 0.86 A heart rate recovery between 12 and 23 beats per minute is considered to be healthy.The heart's recovery rate after exercise is a reliable indicator of mortality risk in both healthy individuals and those undergoing diagnostic testing. This method, though expensive, effectively predicts Cardiorespiratory fitness by assessing heart rate response during a controlled stepping exercise or measuring heart rate recovery after exercise.

3) Glycated haemoglobin (Hba1c)

HbA1c is a simple blood test that measures your average blood sugar levels over the past 3 months. Normal A1C level is below 5.7%, a level 5.7% to 6.4% indicates prediabetes and level 6.5% or more than that indicates diabetes. A high haemoglobin level indicates that the body has difficulty regulating glucose levels Also, high level increases risk of long-term diabetic complications like blindness, nerve damage and kidney failure.

Statistical Analysis

The data were analyzed using Instat software. The results were calculated and are expressed as mean+ SD. Paired t test was used to compare the mean value before and after 8 weeks of intervention of inspiratory muscle training. The p value of <0.05 was considered statistically significant.

Results

The mean age of patient was 49.06 in years. The mean height was 162.79 and mean weight was 69.58 respectively along with that mean BMI was 26.20 in this study.

Hba1c mean and standard deviation before and after the intervention were 6.72±0.10 and, 6.69±0.08 respectively, with a mean difference of 0.03 and a t value of 2.79, using the paired T test as the outcome measure. The P value

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was 0.0077, indicating a Not significant. Mean and standard deviation for heart rate recovery were 17.30±1.79 and 21.97±1.18, respectively, with a mean difference of 4.67 and a t value of 19.72, The P value was <0.0001, indicating a extremely significant result. Functional capacity also improved showing extremely significant result with P value <0.0001 after inspiratory muscle training with and mean and standard deviation before and after the intervention 428.13±76 and 478.39±74.22, respectively. The mean difference was 50.25 and a t value of 12.06. Functional capacity was calculated using 6 minute walk test which was measured and compared in terms of both meters and the amount of achieved percentage of predicted values according to participants age, height and weight. Mean and standard deviation when 6-minute walk distance was calculated according to percentage predicted was 73.21±7.33 and 81.65±5.56 respectively, with a mean difference of 8.43 and a t value of 13.03 with extremely significant difference with p value <0.0001.

Table 1: Baseline Characteristics of Participants

Baseline Characteristics	Mean ± SD
Age	49.06±9.34
Height	162.79±10.42
Weight	69.58±5.86
BMI	26.20±2.32

Table 2: Comparison of pre and post-test Intervention of Hba1c, heart rate recovery, functional capacity

Outcomes	**Pre-Intervention (Mean±SD)**	**Post Intervention (Mean±SD)**	**Mean Difference**	**t value**	**P value**
Hba1c	6.72±0.10	6.69±0.08	0.03	2.79	0.0077 Not Significant
Heart Rate Recovery	17.30±1.79	21.97±1.18	4.67	19.72	<0.0001 Extremely Significant
Functional capacity (6 MWD in Meters)	428.13±76	478.39±74.22	0.25	12.06	<0.0001 Extremely Significant
Functional capacity (6 MWD in % pred)	**73.21±7.33**	81.65±5.56	8.43	13.03	<0.0001 Extremely Significant

Discussion

In the current study we have evaluated effect of inspiratory muscle training on blood glucose levels functional capacity and heart rate recovery in physically inactive diabetic patient. This study found out that Inspiratory muscle training was found out to be effective in improving functional capacity and heart rate recovery in physically inactive diabetic patients . Though this study did not show that much improvement in Hba1c after inspiratory muscle training.

In individuals with type 2 diabetes, a delayed heart rate recovery (HRR) is linked to an increased likelihood of cardiovascular events. This means that reducing HRR can not only predict mortality, but also identify high-risk patients and determine who may benefit from treatments to improve HRR. It is important to note that diminished HRR is associated with endothelial dysfunction, diabetes, fasting plasma glucose, the triglycerides to high-density lipoproteins ratio, and most recently, myocardial perfusion.[12]IMT improves respiratory function, patient well-being, and cardiovascular health. Dempsey et al. found that IMT enhances inspiratory muscle strength, efficiency, ventilatory response to exercise, recovery oxygen uptake kinetics, and quality of life. The activation of type IV phrenic afferents during strenuous contractions of inspiratory muscles leads to increased sympathetic vasoconstrictor activity, improving delayed heart rate recovery. This mechanism

Journal of Chemical Health Risks
www.jchr.org
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underscores the potential benefits of IMT on physiological responses.[13] Exercise limitation is a key indicator of cardiovascular disease, with a worse outcome linked to higher levels of exercise intolerance or lack of physical activity. The causes of exercise limitation in CVD are complex, potentially stemming from negative changes in cardiac, vascular, musculoskeletal, endocrine, and/or pulmonary function. These changes can lead to worsened breathing difficulties, reduced oxygen supply to muscles, and decreased muscle oxygen utilization.[14] To our knowledge this is the first study that investigates effect of 8 weeks of inspiratory training on heart rate recovery in type 2 diabetes mellitus and the results were extremely significant and possible mechanism behind this would be effect of autonomic function that controls heart rate of patient as heart rate recovery is delayed in diabetic patients.

In type 2 diabetes, functional ability is crucial for determining mortality and morbidity. Research shows that patients with type 2 diabetes have lower functional capacities compared to the general population 9. Diabetes, along with other conditions, can hinder physical abilities and impact lung function. Impaired gas transport and abnormal lung function are associated with diabetes mellitus due to the generation of reactive oxygen species from nonenzymatic protein glycation caused by chronic hyperglycemia. This oxidative damage and advanced glycation trigger chronic inflammation. Hyperglycemia also significantly affects the development and progression of microvascular complications in diabetes. Histopathological studies have linked diabetes mellitus to thickening of the basal lamina of alveolar epithelial cells[15] In contrast to the healthy individuals, the diabetic patients exhibited reduced capacity for physical activity. It was discovered that individuals with diabetes and coexisting left ventricular systolic dysfunction (LVSD) covered shorter distances during the walking test. people with diabetes may have poor exercise capacity due to the association between diabetes and negative cardiac consequences.[16]

Another possible mechanism can be Inadequate glucose metabolism in patients with DM may reduce exercise capacity. Hyperglycemia increases production of advanced glycation end products and protein glycation, leading to vessel stiffness in organs like the lungs[17] Compliance greatly impacts coronary artery blood flow modulation, decreasing exercise capacity by affecting myocardial work. Patients with diabetes and peripheral vascular insufficiency had reduced walking distance during the test[18,19]

Still, a number of theories, including decreased blood perfusion, altered neuromuscular activity, and enhanced insulin resistance, have been put forth It has been speculated that IMT may halt or reverse the possible processes causing diaphragm weakening. Additionally, it might raise insulin sensitivity, which would in turn boost glucose transfer during diaphragm contraction[20]

IMT strengthens the diaphragm, delaying the onset of diaphragmatic fatigue and triggering the contraction of accessory inspiratory muscles. As a result, during exercise, less blood must flow to the inspiratory muscles, and more blood perfuses the peripheral muscles

Moreover, IMT has shown to reduce sympathetic-mediated vasoconstriction in peripheral skeletal muscles, which enhances blood flow to these muscles and ultimately raises exercise capacity, according to multiple studies conducted on both healthy and sick populations.[21]

Not every patient can tolerate traditional exercise, and the majority report having trouble sticking to their fitness regimens Inspiratory muscle training is a good alternative to traditional workouts for improving strength and resilience. Andressa S.O. Schein et al conducted a study on the effects of inspiratory muscle exercise on glucose levels in patients with type 2 diabetes. The decrease in glucose levels was likely due to increased insulin secretion and the use of antidiabetic medications.[22,23]

According to findings possible mechanism that reduces glucose levels indicated that parasympathetic activation reduces hepatic glucose release and enhances insulin secretion in hyperglycaemic circumstances, controlled ventilation promotes vagal stimulation, insulin secretion, and glucose reduction[24]

The third component of this study glucose levels (Hba1c) were assessed prior giving intervention and this study did not show significant improvement as compared to other parameters. The possible reason behind this could be insufficient intervention sessions. Reduction in glucose can most likely could have happened as a result of the meal's increased production as well as the patients use of

Journal of Chemical Health Risks

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antidiabetic medication. Furthermore, research is required to assess this parameter.

Conclusion

The Present Study Concluded that, Inspiratory muscle training is effective in type 2 diabetes patients. Therefore, Inspiratory muscle training may be a safe, time-efficient, and effective strategy for improving functional capacity and heart rate recovery in type 2 diabetic patients.

Conflict of Interest

The authors declare no conflict of interest

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