e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2024; 16(11); 298-306

Original Research Article

Comparison of the Effect of Incentive Spirometry and Active Chest Mobilization Techniques on Pulmonary Function and Functional Capacity in Patients with Type 2 Diabetes Mellitus

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Received: 25-08-2024 / Revised: 23-09-2024 / Accepted: 26-10-2024

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Conflict of interest: Nil

Abstract:

Background: Diabetes mellitus is a group of metabolic disease characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The most prevalent form of diabetes is type 2 diabetes mellitus (T2DM), which accounts for 90–95% of all occurrences of diabetes mellitus, and therefore of primary interest. Shah and Sonawane posit that the pulmonary function abnormalities reported in T2DM patients is usually associated with chronic hyperglycemia. In patients with T2DM, the function of the inspiratory muscles is usually observed to be compromised (decreased strength and/or endurance) which results in poor exercise tolerance and reduced functional capacity.

Aim of the study: To compare the effect of active chest mobilization techniques and incentive spirometry on pulmonary function and functional capacity in patients with type-2 diabetes mellitus.

Methods: Patients were randomly allocated in 2 groups, Group A and Group B with 30 patients each. Measurement of all outcome measures (PP, HbA1c, FVC, FEV_1, PEFR, HRQoL and 6-MWT were recorded. Group A was instructed to perform 15 minute session of incentive spirometry twice a day, along with diaphragmatic breathing exercise (10 repetitions) for 6 days per week. Self-Chest mobilization exercises was performed by Group B for three days per week for 6 weeks along with diaphragmatic breathing exercise (10 reps) , twice a day. The obtained data were analyzed using paired and unpaired t test.

Results: After intervention, Group A (incentive spirometry) showed significant improvement in PP(Post Prandial) blood glucose level and FEV_1 and Group B showed significant improvement in 6-MWT.

Conclusion: Both interventions (incentive spirometry and ACMT) were effective in the effectiveness of the two interventions across most measures after 6 weeks.

Keywords: Pulmonary Function, Functional capacity, Incentive spirometry, Active chest mobilization techniques, Post prandial blood glucose level, Glycosylated Haemoglobin, Health related quality of life.

Introduction

Diabetes mellitus is a group of metabolic disorders characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both [1]. Type 2 diabetes mellitus (T2DM), which accounts for 90-95% of all diabetes cases, is the most prevalent form of diabetes and has become a global health pandemic [2,3]. In T2DM, insulin resistance is the primary cause of hyperglycemia, often combined with a relative decline in insulin secretion [3]. This dual defect leads to progressively higher blood glucose levels, which may not be immediately noticeable due to the gradual onset of symptoms. Common early signs of hyperglycemia include polyuria (excessive urination), polydipsia (excessive thirst), and polyphagia (excessive hunger), which often go unrecognized or are misdiagnosed. If left untreated, chronic hyperglycemia can lead to long-term complications, including diabetic neuropathy, retinopathy, nephropathy, cardiovascular disease, and peripheral vascular disease [4].

One less recognized consequence of T2DM is its impact on pulmonary function [5]. Diabetes-induced microangiopathy, combined with non-enzymatic glycosylation of tissues, can affect lung tissues, particularly the microvascular circulation and connective tissue in the lungs. These structural changes may result in detectable pulmonary abnormalities [5,6]. Studies have shown that individuals with T2DM often experience reduced pulmonary function, including impaired inspiratory muscle strength and endurance [7]. This dysfunction can limit exercise capacity and lead to lower quality of life (QoL) [9]. As a result, the relationship between T2DM and pulmonary function has become an important clinical concern, given the potential implications for managing diabetic patients' overall health [7].

The increasing prevalence of T2DM—projected to affect 552 million people worldwide by 2030—coupled with the known pulmonary complications of the disease, makes the identification and management of pulmonary dysfunction in diabetic patients crucial [5]. Various therapeutic approaches have been explored to mitigate these complications, including traditional interventions like medications, insulin therapy, and lifestyle modifications (such as exercise and diet) [10]. Respiratory interventions, such as incentive spirometry (IS) and chest mobilization techniques, have been used to improve lung function and overall respiratory health in a variety of patient populations.

Incentive spirometry (IS) is a widely used device that helps improve lung function by encouraging deep breathing, which in turn promotes lung expansion and helps prevent pulmonary complications. It is commonly used postoperatively or in patients with conditions such as chronic obstructive pulmonary disease (COPD), pneumonia, or after surgery [11]. While the evidence supporting IS in diabetic patients is mixed, some studies suggest that it may help improve pulmonary function and potentially stabilize blood glucose levels [12]. Similarly, chest mobilization techniques (ACMT) are commonly used in chest physical therapy to improve ventilation and chest wall mobility. These techniques, which include both passive and active interventions, aim to enhance respiratory muscle function, thoracic compliance, and overall lung efficiency. Chest mobilization exercises, through the lengthening of the intercostal muscles, may also improve respiratory muscle contraction, lung ventilation, and reduce the use of accessory muscles during respiration [13]. However, studies specifically examining the impact of ACMT on pulmonary function in T2DM patients are scarce, with little research focused on its combined use with IS [14-20].

The purpose of this study is to evaluate and compare the effectiveness of two respiratory interventions—Incentive Spirometry (IS) and Active Chest Mobilization Techniques (ACMT)—in improving pulmonary function and functional capacity in patients with T2DM. While both interventions have shown promise in improving lung function in various populations, their combined impact on diabetic patients has not been studied to date. The goal of this research is to determine which method offers the most significant benefit in improving pulmonary health and overall physical function in individuals with T2DM. By addressing this gap in the literature, the study aims to provide evidence-based recommendations for managing pulmonary complications in diabetic patients and improving their quality of life.

Materials and Methods:

The design of the study was experimental which was conducted at the College of Physiotherapy, Pt. B.D. Sharma PGIMS, Rohtak, from August 2023 to July 2024, and was approved by the Institutional Ethical Committee. Informed consent was obtained from all participants. A total of 60 adults with Type 2 Diabetes Mellitus (T2DM) were included, all of whom were on oral hypoglycemic agents and not insulin therapy, had a confirmed diagnosis of T2DM for at least six months, and had an HbA1c level of ≥6.5%. Inclusion criteria also required participants to be aged 18 years or older, non-smokers, and non-alcoholic, with the ability to follow instructions. Exclusion criteria included pre-existing pulmonary infections, severe diabetic complications such as neuropathy, nephropathy, or retinopathy, and co-morbid conditions like COPD or mental illnesses. Participants were recruited using convenience sampling from the Medicine Department at Pt. B.D. Sharma PGIMS, Rohtak, and were assigned to one of two groups: Group A (Incentive Spirometry with diaphragmatic breathing) and Group B (Active Chest Mobilization with diaphragmatic breathing).

Procedure:

Procedure was explained to all the subjects. Outcome measures included pulmonary function (measured by spirometry for Forced Vital Capacity [FVC], Forced Expiratory Volume in 1 second [FEV1], and Peak Expiratory Flow Rate [PEFR]), functional capacity (assessed by the 6-minute walk test [6MWT]), blood glucose levels (measured postprandially with a glucometer), HbA1c levels were measured in the PGIMS laboratory and Health-Related Quality of Life (QoL), which was assessed using the WHOQOL-BREF questionnaire.

In both the groups treatment was given for 6 weeks. Readings were taken on day 0 and at last day of 6th week.

Group A

Participants in Group A performed incentive spirometry along with diaphragmatic breathing exercises (10 repetitions) for 15 minutes, twice daily, 6 days a week, for 6 weeks.

The procedure followed the American Association for Respiratory Care (AARC) protocol, involving slow inhalation to raise the spirometer ball and breath-holding for 3 seconds (Figure 1).

Figure 1: Incentive Spirometry

Group B:

Group B performed active chest mobilization exercises along with diaphragmatic breathing exercises (10 repetitions) twice daily, 3 days a week, for 6 weeks. Exercises included chest wall stretching in various directions [anterolateral (Figure 2), lateral costal (Figure 3), posterolateral (Figure 4), anteroposterior (Figure 5) and anteroposterior upper chest wall stretching (Figure 6)].

Each exercise performed for 3 repetitions.

Figure 2: Anterolateral chest wall

Figure 3: Lateral costal chest wall stretching stretching

Figure 4: Posterolateral chest wall

Figure 5: Anteroposterior chest wall stretching stretching

Figure 6: Anteroposterior upper chest wall stretching

Data Analysis and Result: The data was analyzed using SPSS software version 25. Mean and standard deviation of all the variables were calculated. The level of significance was set at $p<0.05$. Paired't' test was used for comparison within the groups and unpaired't' test was used for comparison between the two groups of all the variables.

Table 1: Distribution of mean age in study participants

Variable	Group A Mean±SD	Group B Mean±SD	t- score	P- value
Age	43.00±13.68	49.33±12	-1.905	0.062^{NS}

(NS=non-significant)

Table 1 shows age wise distribution of study participants. Mean age of Group- A and Group B were 43.00±13.68 and 49.33±12 respectively.

Table 2: Gender wise distribution of study participants

Gender	Total	Group A	Group B	χ^2 value	p value
	N (%)	N (%)	N (%)		
Male	29(48.33%)	15(50%)	14(46.67%)	0.067	0.79^{NS}
Female	31(51.67%)	15(50%)	16(53.33%)		

(NS=non-significant)

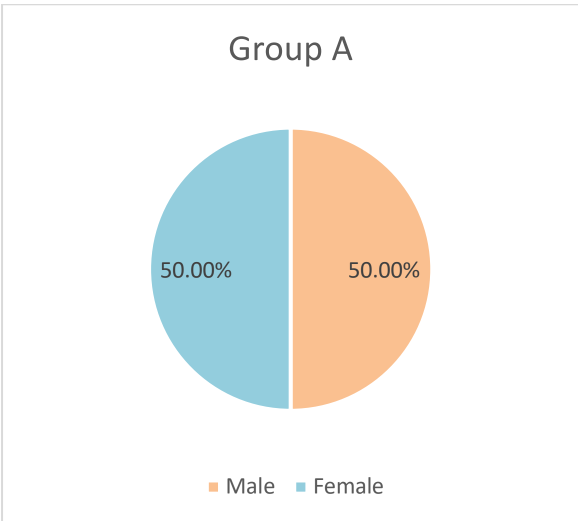

Figure 7: Gender wise distribution of participants in Group A

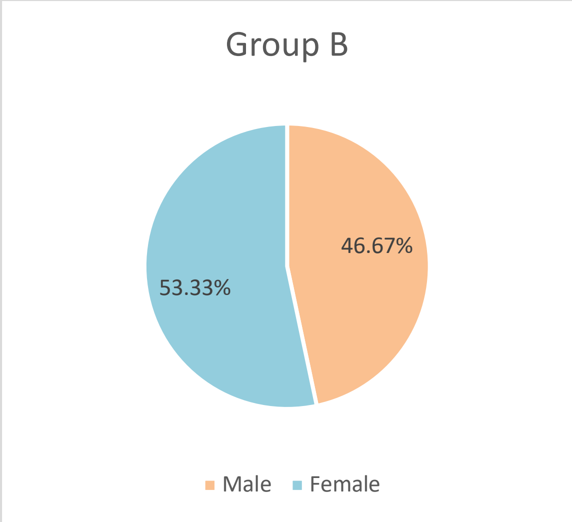

Figure 8: Gender wise distribution of participants in Group B

Incentive Spirometry group: A significant difference is observed after 6 weeks of incentive spirometry intervention when compared statistically (Table 3). The pre and post – result of pulmonary function shows significant differences FVC ($p<0.001$), FEV_1 ($p<0.001$) and PEFR($p<0.001$), respectively. Functional capacity improved in incentive spirometry group significantly ($p<0.001$). Therefore, a positive outcome is observed when incentive spirometry was applied as an intervention.

Table 3: Comparison of measurements in incentive spirometry group.

Incentive Spirometry Group				
		Baseline(n=30)	**6 weeks(n=30)**	**p-value**
Pulmonary function test	**FVC**	3.04 ± 0.88	4.23 ± 1.05	<0.001**
	FEV_1	2.75 ± 0.89	3.10 ± 0.84	<0.001**
	PEFR	7.46 ± 2.61	8.68 ± 2.19	<0.001**
Functional capacity	**6-MWT**	237.63 ± 59.98	250.67 ± 58.62	<0.001**
Blood Glucose level	**HbA1c**	9.66±2.93	7.79±1.54	<0.001**
	PP	234.10 ± 84.44	234.10 ± 84.44	<0.001**
Health related quality of life	**WHO-BREF**	48.50 ± 15.02	63.33 ± 16.09	<0.001**
Paired t-test, performed among the same individual's data observed on the same day and after 6 weeks; *Significant at p<0.05, **Significant at p<0.001, NS=Non significant				

Active Chest Mobilization Therapy Group: When the active chest mobilization therapy group was compared for pre and post- difference (Table 4), using paired t-test, highly significant differences were observed in pulmonary function, functional capacity and health related quality of life. Comparison between incentive spirometry and active chest mobilization techniques after 6 weeks: While comparing, the mean of incentive spirometry intervention group and ACMT intervention group by using independent t-test non- statistical differences were observed at baseline ($p>0.05$).

Table 4: Comparison of measurements in active chest mobilization therapy group.

Active Chest Mobilization Techniques Group				
		Baseline(n=30)	**6 weeks(n=30)**	**p-value**
Pulmonary function test	**FVC**	3.36±0.92	3.57±0.87	<0.001**
	FEV_1	2.45 ± 0.74	2.91 ± 0.77	<0.001**
	PEFR	6.85 ± 2.62	7.64 ± 2.79	0.033*
Functional capacity	**6-MWT**	243.33 ± 58.62	291.33 ± 54.43	<0.001**
Blood Glucose level	**HbA1c**	9.51±2.86	8.68±2.40	0.002*
	PP	235.06 ± 101.20	221.73 ± 99.97	0.090NS
Health related quality of life	**WHO-BREF**	43.27 ± 16.36	61.17 ± 14.97	<0.001**
Paired t-test, performed among the same individual's data observed on the same day and after 6 weeks; *Significant at p<0.05, **Significant at p<0.001, NS=Non significant				

Between groups comparison after intervention (6 weeks) shows significant difference in pulmonary function(FVC), 6-Minute walk test and post prandial blood glucose level ($p<0.05$) [Table 5]

Table 5: Comparison of measurements among incentive spirometry and active chest mobilization technique group after 6 weeks (after intervention)

Between group comparison				
		IS-Group (mean±SD)	**ACMT-Group (mean±SD)**	**p-value**
Pulmonary function test	**FVC**	4.23 ± 1.05	3.57±0.87	0.01*
	FEV_1	3.10 ± 0.84	2.91 ± 0.77	0.97NS
	PEFR	8.68 ± 2.19	7.64 ± 2.79	0.06NS
Functional capacity	**6-MWT**	250.67 ± 58.62	291.33 ± 54.43	0.007*
Blood Glucose level	**HbA1c**	7.79±1.54	8.68±2.40	0.70NS
	PP	234.10 ± 84.44	221.73 ± 99.97	0.007**
Health related quality of life	**WHO-BREF**	63.33 ± 16.09	61.17 ± 14.97	0.66NS

@Independent t-test, performed among the incentive spirometry intervention group and active chest mobilization techniques group observed after completion of the intervention i.e. after 6 weeks; *Significant at $p<0.05$, **Significant at $p<0.001$, NS=Non significant

Discussion:

Type 2 diabetes mellitus (T2DM), which accounts for 90-95% of all diabetes cases, is the most prevalent form of diabetes and has become a global health pandemic. The present study aimed to compare the effectiveness of two respiratory exercises, incentive spirometry (IS) and active chest mobilization techniques (ACMT), in patients with Type 2 Diabetes Mellitus (T2DM). The findings showed significant improvements in functional capacity, pulmonary function, blood glucose control, and health-related quality of life (QoL) after six weeks of intervention in both groups.

In terms of functional capacity, both groups showed significant improvement in the 6-Minute Walk Test (6MWT), with ACMT demonstrating a slightly greater improvement, suggesting its effectiveness in enhancing endurance by improving chest wall mobility and oxygen distribution to muscles. The result of present study was supported by Aweto et al. (2020) [14] on type 2 diabetic patients which conclude that incentive spirometer causes significant improvement in 6-MWT. According to Yangjin et al. (2023) [13] study done on chest mobilization techniques in chronic stroke patients after corona virus disease showed significant improvement in 6-MWT. Both interventions also positively impacted pulmonary function, with significant improvements in Forced Vital Capacity (FVC), Forced Expiratory Volume (FEV1), and Peak Expiratory Flow Rate (PEFR). Incentive spirometry was slightly more effective in improving FVC, while ACMT showed greater improvements in FEV1 and PEFR, highlighting that both methods contribute to better lung function in T2DM patients. The result was supported by Aliasgharpour et al (2018) [26] on patients undergoing hemodialysis which conclude that incentive spirometer was better in improving FVC. Park Shin J et al. (2017) [15] conducted a study on chest mobilization techniques in stroke patients which showed significant improvement in pulmonary function (FEV1, PEFR). Chronic diabetes can lead to decreased respiratory muscle efficiency and increased rib cage asymmetry, resulting in restricted movement. Regarding blood glucose levels, both interventions resulted in significant reductions in HbA1c and postprandial blood glucose levels (PPBGL). Although Group A (IS) demonstrated a slightly better reduction in PP, both approaches were equally effective in reducing blood glucose, suggesting that respiratory exercises may improve insulin sensitivity in T2DM patients. Notably, there was no significant difference between the groups in HbA1c reduction, indicating that both interventions can effectively aid in glucose management.

In a study by Devadasan et al. (2019) [27], control group was compared with incentive spirometry after 1 month of intervention. This study concluded that the people who were given incentive spirometry had shown a significant reduction in blood glucose level. They reported that sugar level reduced significantly ($p>0.0001$) after 1 month of intervention. This reduction could be due to high resistance of inspiratory muscle exercise which reduces blood glucose levels. It was also posited that respiratory exercises improves insulin sensitivity in patients with insulin resistance, hence leading to reduction in blood glucose level.

Finally, both interventions improved health-related quality of life (QoL), as measured by the WHO-BREF, with ACMT showing a slightly better improvement than IS. While no significant difference was found between the groups, the clinically relevant difference suggests that chest mobilization techniques may offer additional benefits in overall well-being and QoL. Overall, the study supports the use of both incentive spirometry and active chest mobilization techniques as effective interventions for improving pulmonary function, functional capacity, blood glucose control, and QoL in patients with Type 2 Diabetes Mellitus. Both methods offer unique benefits, with IS being slightly superior in pulmonary function outcomes and ACMT showing better results in functional capacity. Further studies with larger sample sizes and longer follow-up periods are needed to confirm these findings and explore the long-term effects of these interventions.

Limitation(s)

Six weeks are short intervention period to determine the improvement in aerobic capacity, health related quality of life and pulmonary function test. Secondly, there was no long-term follow-up of the subjects in both groups, and we do not know how much these subjects adhered to the exercises on their own.

Conclusion(S)

The present study highlights the effectiveness of both Incentive Spirometry (IS) and Active Chest Mobilization Techniques (ACMT) in improving various health outcomes in patients with type 2 diabetes mellitus. There are significant differences in the outcomes between the two groups. Specifically, for postprandial blood glucose levels (PP), there is a significant difference in the reduction of PP between Group A (Incentive Spirometry) and Group B (Active Chest Mobilization Technique) after 6 weeks which stated that Group A Was better than Group B. Similarly, for Forced Vital Capacity (FVC) and the 6-Minute Walk Test (6-MWT), there are significant differences in improvement between the two groups following the interventions in which Group A was better than group B in case of FVC and Group B was better in case of 6MWT. In contrast there are no significant differences in the reduction of Glycosylated Hemoglobin (HbA1c), the improvement of Forced Expiratory Volume in one second (FEV1), the Peak Expiratory Flow Rate (PEFR), and the health-related quality of life (QOL) as assessed by WHO-BREF scores between both groups after 6 weeks. Overall, this study supports the incorporation of both IS and ACMT into rehabilitation protocols for diabetic patients, as they contribute positively to functional, pulmonary, and metabolic outcomes, thereby enhancing overall health and quality of life. Future research could explore long-term effects and potential combined approaches to maximize benefits for this population.

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