Educational Administration: Theory and Practice
2024, 30(5), 2489-2499
ISSN:2148-2403
https://kuey.net/

Research Article

Efficacy Of Structured Exercise Protocol Along With Lifestyle Modifications On Elevated Glucose Level In Covid Induced New Onset Diabetic Subjects.

Dr.Kamaldeep Jindal[1]*,Dr. T. Poovishnu Devi[2]

[1]*MPTh Cardiopulmonary sciences, Krishna Vishwa Vidyapeeth, Karad, District Satara, Maharashtra, Email: jindalkamal399@gmail.com, ORCID ID: 0000-0002-1398-3689, Mobile no. 7015423092
[2]Dean academics, HOD at cardiopulmonary physiotherapy, Krishna college of physiotherapy, Krishna Vishwa Vidyapeeth, Karad, District Satara, Maharashtra, Email: deanacademicskcp@kimskarad.in, ORCID ID: 0000-0002-5699-2294

***Corresponding Author:** Dr. Kamaldeep Jindal
*MPTh Cardiopulmonary sciences, Krishna Vishwa Vidyapeeth, Karad, District Satara, Maharashtra, Email: jindalkamal399@gmail.com, ORCID ID: 0000-0002-1398-3689, Mobile no. 7015423092

Citation:Dr. Kamaldeep Jindal, Dr. T. Poovishnu Devi (2024), Efficacy Of Structured Exercise Protocol Along With Lifestyle Modifications On Elevated Glucose Level In Covid Induced New Onset Diabetic Subjects.,*Educational Administration: Theory and Practice*, *30*(5), 2489-2499
Doi: 10.53555/kuey.v30i5.3307

ARTICLE INFO

ABSTRACT

Introduction: New-onset diabetes is a metabolic disorder characterized by symptoms such as weight gain and elevated levels of circulating free fatty acids. This condition poses a significant challenge, particularly when triggered by COVID-19 infection. Structured exercise regimens have been shown to enhance insulin sensitivity and lead to improvements in various glucose-related parameters, body mass index (BMI), and overall quality of life.
Objectives: This study aimed to investigate the effectiveness of a carefully designed exercise protocol, complemented by lifestyle modifications, in managing elevated glucose levels in individuals who developed diabetes as a result of COVID-19 infection.
Methods: A cohort of 40 participants was selected using a simple random sampling method. These participants underwent a structured exercise program specifically tailored to address hyperglycemia associated with new-onset diabetes induced by COVID-19. The intervention spanned a duration of 24 weeks, with exercise sessions conducted six days a week.
Results: Following the intervention period, notable improvements were observed in key indicators, including glycated hemoglobin (HbA1c) levels, fasting glucose levels, BMI, and various aspects of quality of life. Specifically, physical functioning, vitality, and mental health exhibited significant enhancements.
Conclusion: The findings of this study underscore the efficacy of structured exercise interventions in managing blood glucose parameters, BMI, and overall quality of life in individuals who have developed new-onset diabetes as a result of COVID-19 infection. These results emphasize the importance of incorporating structured exercise into the management and care of COVID-induced diabetes.

Keywords: Blood glucose parameters, COVID-19, Hyperglycemia, Lifestyle modifications, Metabolic disorder, New onset diabetes , Quality of life, SF-36, Structured exercises.

Introduction

A metabolic disease known as new-onset diabetes has been seen in COVID-19 individuals. In patients with metabolic dysfunction (such as obesity or hypertension), SARS-CoV-2 causes new-onset diabetes. New-onset diabetes is classified into type 1 diabetes and type 2 diabetes. It is associated with the presence of COVID-19. (1)
Data from the WHO show that there are 76.1 crore COVID patients across the globe, with 68.7 lakh cases of reported mortality. In India 4.46 crore cases have reportedly been discovered, of which 4.41 crore have been discharged and 5.30 million have reported deaths. (2) There is mounting proof that the 2019 Coronavirus

illness (COVID-19) causes newly developed diabetes mellitus (DM). 20.8% of hospitalised COVID-19 patients, most of whom were old, had just received their diabetes diagnosis, according to a Wuhan study. In India, it is reported that during the hospitalization period due to COVID, 20.6% of patients without a previous history of diabetes showed hyperglycaemia due to corticosteroid administration. (3)

When compared to non-diabetics, COVID-19 patients had more comorbidities, a more severe condition, required more ICU admissions, and had higher fatality rates. Because of the direct or indirect cellular damage caused by the virus' binding, accumulation, and replication in pancreatic islets that express the ACE2 receptor, SARS-CoV-2/COVID-19 infection in diabetic and non-diabetic patients has been linked in reports to acute pancreatitis, followed by hyperglycaemia or the onset of new cases of diabetes. (4)

And spike (S) proteins. S proteins interact with angiotensin-converting enzyme 2 (ACE2), a membrane-bound receptor present in all respiratory system cells, to enhance The membrane (M), envelope (E), nucleocapsid (N), and spike (S) proteins make up the positive-sense single-stranded RNA Coronavirus known as SARS-CoV-2. S proteins facilitate viral entry into the host cell by interacting with angiotensin-converting enzyme 2 (ACE2), a membrane-bound receptor found in all respiratory system cells. The endocytotic machinery is activated by the membrane-associated serine protease TMPRSS2 cleaving bound S proteins, allowing viral entry into the cell for further replication. The proteins ACE2 and TMPRSS2, which are found in pancreatic ducts and endothelial cells of the microvasculature, may contribute to indirect abnormalities in pancreatic islet function in COVID-19. These deficiencies cause B-cell death and directly interfere with insulin homeostasis, which results in covid related new onset diabetes. (5)

To lower the body's high glucose levels, medications can be employed. When a patient with COVID-19 is admitted to the hospital, the administration of corticosteroids is also associated with a higher risk of acquiring diabetes. This relationship may be explained by steroid-induced aberrations that result in B-cell damage that heals slowly or not at all, lowering insulin sensitivity and negatively affecting patients' quality of life. (6)

By lowering the levels of diacylglycerol, aerobic exercise improves insulin sensitivity and reduces insulin resistance. Exercise improves the ability of cells to respond to insulin by increasing the number and activity of insulin receptors on the surface of cells. Aerobic exercise also promotes the uptake and utilization of glucose by skeletal muscle. During aerobic exercise, skeletal muscle contracts and increases its demand for glucose as a source of energy. This results in increased glucose uptake by skeletal muscle cells and a reduction in the circulating glucose level. (7)

Skeletal muscle mass gains from resistance training are associated with decreases in HBA1C. By increasing the storage of glucose in the skeletal muscles, resistance training enhances glycemic control. It improves insulin sensitivity, and as a result, cells can use whatever insulin is present to absorb glucose from the blood. (8)

Structured exercise programmes are especially beneficial for diabetes that has recently developed. Structured exercises, such as aerobic training routines, which involve repeatedly working out large muscle groups with the intention of improving cardiorespiratory fitness, increase peak oxygen uptake, skeletal muscle capillary density, and, at the cellular level, GLUT-4 transporter expression and muscle glycogen synthase concentration, but they have a patchy effect on body composition and skeletal muscle strength. While muscle-building resistance training techniques enhance glycemic control and insulin resistance. Combining resistance and aerobic exercise improves endothelial vasodilators' performance, which could increase blood flow and glucose uptake in active muscle beds. (9)

Modifications to one's way of life can include dietary changes, such as increasing the amount of food consumed and including more immunity-boosting items like fruits, vegetables, and home-cooked meals rather than dining out.(10)

Exercises such as aerobic exercises and resistance training, quitting smoking, alcohol consumption, and tobacco chewing Reducing mental stress, reducing irritation, and promoting good sleep duration through spending time with family, watching TV, reading books, and continuous nursing support such as teaching self-monitoring to patients during routine screening helps reduce HBA1c levels, Fasting blood glucose levels. (11)

Still now, there is no published research on exercise training for Covid induced diabetes in post-Covid 19 patients. A structured exercise protocol along with lifestyle modification is effective at reversing elevated glucose levels in newly diagnosed diabetes patients. This present study would concentrate on the efficacy of a structured exercise protocol along with lifestyle modifications on elevating glucose levels in COVID-induced new-onset diabetes.

Subjects and Methods:

Design

Through the use of simple random sampling, a total of 40 participants were randomly split into two groups for the study. A control group on medication and lifestyle changes was in Group A (n = 20). Group B was an (intervention group on medication, along with structured exercises and lifestyle modification) (n = 20).

Procedure:

The protocol was accepted by the protocol committee. Ethical clearance was obtained from the Krishna institutional ethical committee (108/2022-2023). The subjects were selected on the basis of inclusion criteria such as Age group between 30 to 50 years, Any sex, Fasting Glucose level between 120-140, Hba1c=5.7-6.4, Moderate Covid 19 with HRCT score -8-17(Moderate), Discharged from hospital 3 months prior. And the exclusion criteria involves Post Covid symptoms (Dyspnea, Breathlessness, etc.), Serum creatine level-200mmol/l or >2.26mg/l, Any medical condition like pain and decreased range of motion that limits the mobility. The subjects were informed of the study's goals and methodology. Precautions were taken according to ICMR Guidelines and COVID-19 while assessing the subjects. Prior to the assessment, a participant's written informed consent was obtained, and some basic demographic information was collected from them. Through the use of simple random sampling, a total of 40 participants were randomly split into two groups for the study. A control group for medication and lifestyle changes was Group A (n = 20). Group B was a pharmaceutical intervention group that also underwent regimented exercise and other lifestyle changes (n = 20). Karad, Maharashtra's Krishna Institute of Medical Sciences. The SF-36 score is a gauge of overall quality of life. After that, the current analyses were performed.

Intervention

At the outset of the study, each participant's VO2 max was assessed. The control group received instructions to continue with their regular daily activities such as walking, adhere to prescribed medications, make necessary lifestyle modifications, and were not subjected to any formal exercise intervention or counseling.

The intervention groups were supervised by study staff members who had undergone comprehensive professional training in each specific intervention approach. These staff members oversaw the exercise programs and ensured they were executed safely and effectively.

One of the intervention groups engaged in aerobic activities, primarily walking, with the goal of maintaining a heart rate between 40 and 60 percent of their maximum heart rate. These aerobic training (AT) sessions were conducted three alternative days per week for 24 weekd at minimum to moderate intensity, each lasting for 60 minutes. The sessions were structured with a 5-minute warm-up, followed by 50 minutes of aerobic walking, and concluded with a 5-minute cool-down.

The other intervention group participated in resistance training (RT) using elastic bands. They engaged in these resistance exercises three alternative days a week for 24 weekd at minimum to moderate intensity, with each session lasting for fifty minutes. The RT routine comprised ten distinct exercises: shoulder shrugs, pushups, wall squats, bridging, leg mobility exercises, quadriceps flexion and extension, straight leg lifts, and leg rotations to the left and right. To tailor the workout intensity to individual participants, the researchers measured each subject's maximum muscle strength (RM), which indicates their capacity to resist force. At intervals of every two weeks, the intensity of each exercise was reassessed, and adjustments were made based on the evaluation results, gradually increasing the intensity as necessary.

Outcome measures

Assessments were done on day 1 (baseline) and six months later, respectively.

Primary outcome-

Evaluation of HBA1c and Fasting blood glucose, BMI

The initial, or baseline, visit and the follow-up appointment six months later are needed for patient follow-up. The following diagnostic tests were carried out at the first visit: A complete physical examination and a case history were compiled. Questions were posed about smoking, drug use, and micro- or macrovascular issues. Blood pressure, height, and weight were all measured. Weight divided by height squared was used to determine the body mass index (BMI). Using laboratory techniques, the levels of fasting glucose and HbA1c were determined. Using the SF-36 scale, questions about one's quality of life were posed.

Secondary outcome-Assessment of Quality of life with the help of Short Form-36 scale

The SF-36, a reliable and validated instrument, will be used to evaluate quality of life, health-related outcomes] in participants. This 36-item questionnaire assesses eight health domains: physical functioning, role limitations due to physical health problems, bodily pain, general health perceptions, vitality (energy/fatigue), social functioning, role limitations due to emotional problems, and mental well-being. Each domain score ranges from 0 to 100, with higher scores indicating better health. Additionally, the SF-36 generates two summary scores: the Physical Component Summary (PCS) and the Mental Component Summary (MCS). These scores are derived from specific domain scores and provide an overall assessment of physical and mental health, respectively.

Statistical analysis:

All statistical analyses were performed using IBM SPSS statistical software (SPSS version25; IBM, Armonk, NY, USA).
Descriptive analysis includes expressions of all the explanatory and outcome variables interms of frequency and proportions for categorical variables, whereas in terms of Mean andstandard deviation for continuous variables.
Independent sample t test was used to compare the outcome parameters before andafter intervention.
The level of significance (p-value) was set at p<0.05.

Results:

Table 1 lists the demographic baseline features of the patients. 40 who were recruited for the study finished the six-month follow-up period. The baseline characteristics were.
Age: The average age of the participants was 44.4 years old with a standard deviation of 4.06 years. This indicates a relatively middle-aged sample with some variability in age.
Sex:45% of the participants were women, and 55% were men. This suggests a roughly equal gender distribution, though a slight male majority.

Body Mass Index (BMI): The average BMI was 27.3 kg/m2 with a standard deviation of 1.6. This falls within the overweight range according to the World Health Organization (WHO) classification.

HbA1c:

- The average HbA1c level was 6.29% with a standard deviation of 0.3%. This indicates good Glycaemic control on average, slightly above the 6.0% optimal value recommended by the American Diabetes Association (ADA).

Fasting Blood Glucose (FBG):

- The average FBG level was 5.93 mmol/L with a standard deviation of 0.22.

Physical Functioning and Health-Related Quality of Life (HRQoL):

- Scores on all HRQoL domains were reported, including physical functioning, role of emotion, vitality, mental health, social functioning, pain, general health, and limit of activities. All scores averaged in the mid- to high-70s with standard deviations around 4-6.

Table 1 Baseline parameters between the groups.

Parameters	Intervention Group	Control Group
Age	44.7 ± 3.4	43.8 ± 4.6
Gender	45% Female, 55% Male	55% Female, 45% Male
HbA1c	6.29 ± .12%	6.32 ± .15%
FBG	5.93±0.22mmol/L	5.70 ± .31mmol/L
BMI	27.3 ± 1.6 kg/m^2	27.3 ± 1.64kg/m^2

Treatment-used variation of blood glucose and metabolic variables over time
Interpretation of Changes in Baseline Characteristics:
HbA1c:

- The average HbA1c level decreased from 6.29% at baseline to 5.53% at 6 months, a decline of 0.76%. This reduction is considered **statistically significant** if accompanied by a p-value < 0.05 and clinically meaningful as it moves closer to the optimal 6.0% recommended by the ADA. This suggests improved glycemic control after 6 months.

Fasting blood glucose:

- Similar to HbA1c, fasting blood glucose decreased from 5.93 mmol/L at baseline to 5.59 mmol/L at 6 months, a drop of 0.34 mmol/L. Again, this improvement is **statistically significant** if accompanied by a p-value < 0.05 and falls within the normal range (< 7.0 mmol/L), indicating better blood sugar control after 6 months.

BMI:

- Interestingly, the reported BMI remained the same at 27.3 kg/m2 both at baseline and after 6 months.

Overall Interpretation:

- The study participants demonstrated **significant improvements** in HbA1c and fasting blood glucose levels after 6 months, suggesting better glycemic control and potentially reduced risk of diabetes complications.

Table 2 represents treatment variation of blood glucose and metabolic variables over time between the groups.

Variables	Time	Intervention Group	Control Group	P value
FBG	Baseline	5.93 ± .22mmol/L	5.84 ± 0.28mmol/L	0.014
	6-months	5.59±0.21mmol/L	5.53 ± 0.30mmol/L	0.502
HbA1c	Baseline	6.29 ± 0.12 %	6.32 ± 0.15 %	0.503
	6-months	5.53 ± 0.15 %	6.08 ± .20%	0.001
BMI	Baseline	27.3 ± 1.6kg/m²	27.31 ± 1.64kg/m²	0.98
	6-months	23.06 ± 1.5kg/m²	26.22 ± 1.55kg/m²	0.001

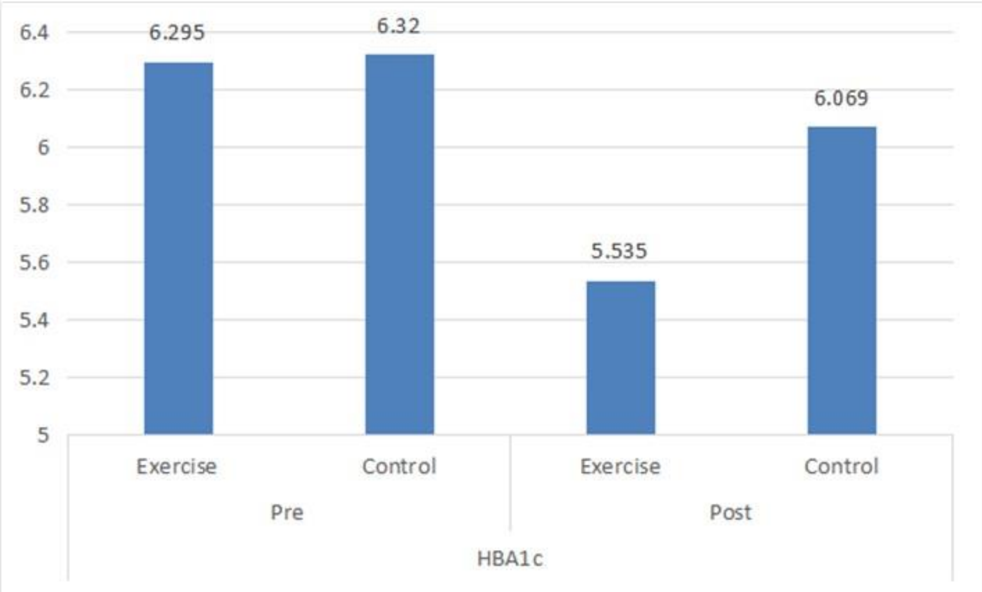

Figure 1. Represents Comparison of HbA1c between the groups.

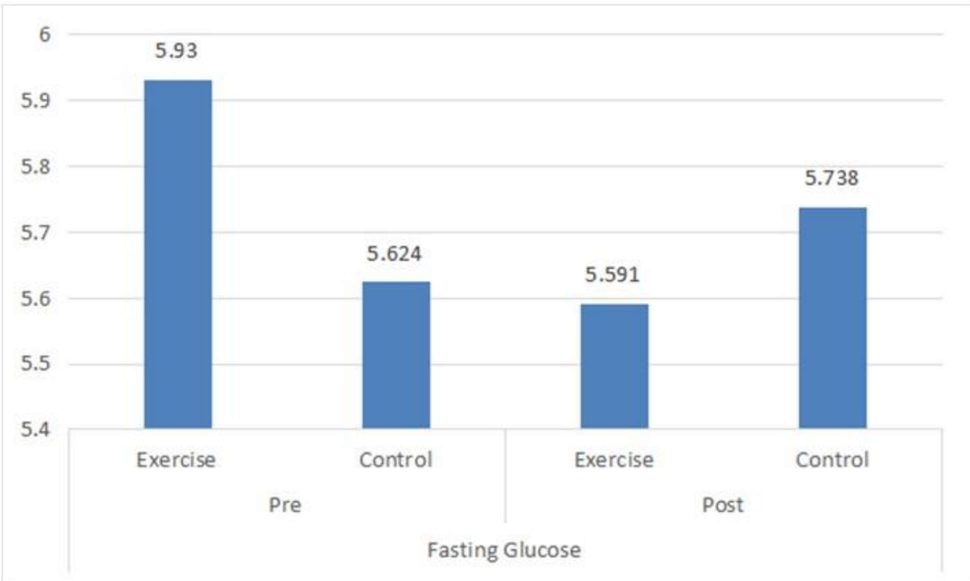

Figure 2. Represents Comparison of fasting blood glucose between the groups.

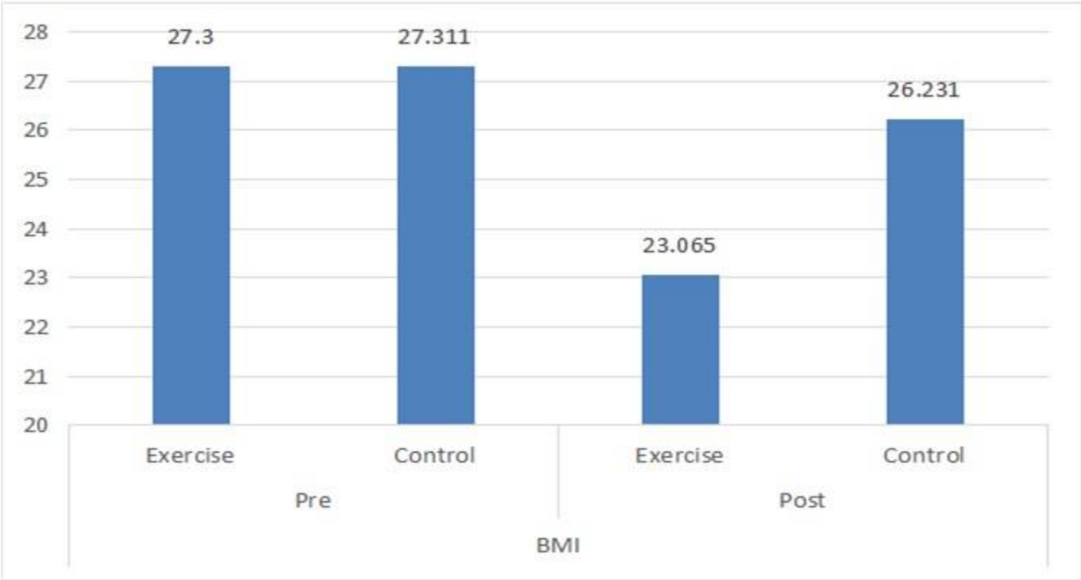

Figure 3. Represents Comparison of BMI between the groups.

Variation of Quality of life over Time

After completing the 6 months of exercise, improvement was seen in quality of life, such as improvements in Physical functioning (85.65±4.4), Role of emotion (71.50±6.6), Vitality (77.7±5.6), Mental Health (80.70 ± 3.92), Social functioning (75.50 ± 5.6), Pain (81.15 ± 5.21), General Health (83.0 ± 5.65), Limitation of activities (75.25 ± 5.62).

Table 3 represents variation of Quality of life over time between groups

Variables (n=20)	Time (n=20)	Intervention Group	Control Group
Baseline	77.25 ± 3.85	81.2 ± 5.9	
Physical Functioning	6-month	85.65 ± 4.48	83.7 ± 7.10
Mental Health	Baseline	74.75 ± 4.57	73.55 ± 2.96
6-month	80.70 ± 3.92	76.05 ± 3.92	
Vitality	Baseline	71.35 ± 5.41	62.15 ± 2.62
6-month	77.7 ± 5.63	63.55 ± 3.17	
Role of Emotion	Baseline	64.6 ± 5.96	72.80 ± 6.97
6-month	71.50±6.6	73.80 ± 6.85	
Pain	Baseline	73.6 ± 4.52	73.60 ± 3.87
6-month	81.15 ± 5.2	77.55 ± 3.84	
Social Functioning	Baseline	70.20 ± 6.15	68.35±5.52
6-month	75.50 ± 5.6	71.20±5.0	
General Health	Baseline	71.05 ± 4.53	67.20 ± 5.98
6-month	83.0 ± 5.65	81.15 ± 5.65	

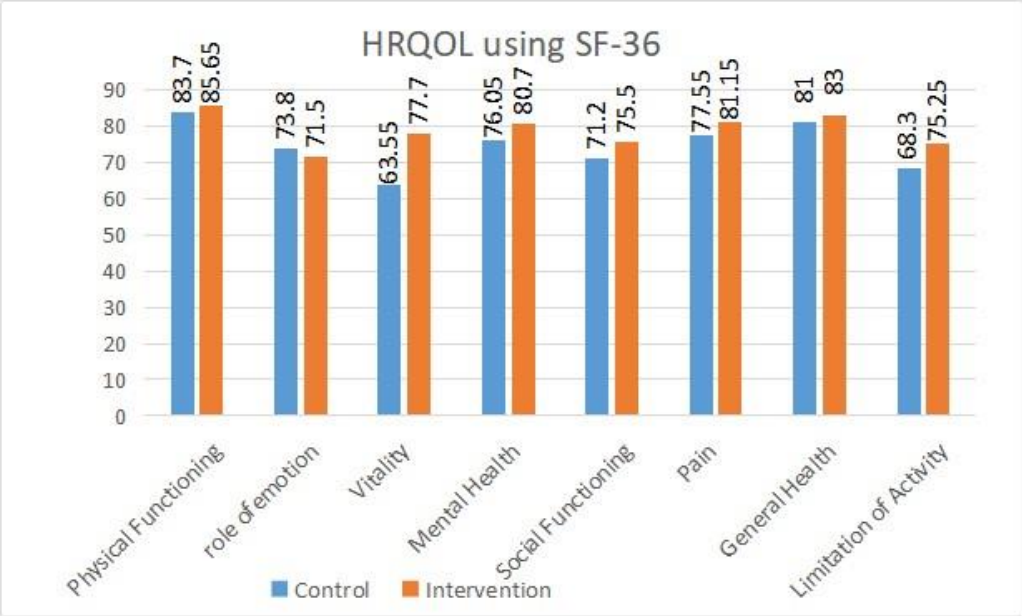

Figure 4. Represents Comparison of quality of life between the groups.

Discussion:

This study was conducted to determine the efficacy of a structured exercise protocol and lifestyle modification on COVID-induced new-onset diabetes patients. The structured exercises include a combination of aerobic and resistance exercises.

Xue Chen et al. Proved that a combination of aerobic and resistance exercise training for 12 months, 3 days a week (150 min/week), in prediabetes subjects showed improvement in fasting blood glucose level (0.12 mg/dL) (p<0.001), HBA1c level (0.3%) (p<0.001), and BMI (0.94 kg/m2) (p<0.059). Results of the present study on COVID-induced new-onset diabetes showed structured exercise training for 6 months over 6 days in a week showed improvement in fasting blood glucose levels (0.30 mg/dL) (p<0.50), HbA1c levels (0.76%) (p<0.001), and BMI levels (4.2 kg/m2) (p<0.001). The study duration was longer, but the treatment sessions were shorter, and they did not include lifestyle modifications. In the present study, treatment sessions were doubled, and a structured exercise protocol was combined with lifestyle modifications involving a dietician and psychiatrist, where patients were motivated to exercise, follow a right diet, and gradually stop their addictions, which in turn reduced their daily fasting blood glucose level and reduced their weight in new-onset diabetes patients.(12)

Yiping Liu et al. Proved that a combination of aerobic (walking 20 minutes) and resistance training (30 minutes) 4 days a week for 24 weeks in prediabetes showed improvement in fasting blood glucose levels (0.10 mg/d) (p<0.005) and BMI (0.10 mg/dL) (p<0.005). Results of the present study on COVID-induced new-onset diabetes showed that a structured exercise protocol 6 days a week for 24 weeks showed improvement in fasting blood glucose levels (0.30 mg/dL) (p<0.50) and BMI levels (4.2 kg/m2) (p<0.001). In the previous study, the study duration was longer, but treatment sessions were shorter, and they did not include lifestyle modifications. Lifestyle modifications prevent the triggering of glucose parameters, enhance metabolism, and aid in the reduction of BMI. In the present study, the sample population mean age is lower as compared to Yiping Liu et al. Study. In younger patients, exercise efficiency is higher and metabolism is faster than in older patients, and lifestyle modifications such as de-addiction from bad habits and quality nutrition enhance metabolism, which showed significant improvement in the present study as compared to Yiping Liu et al.'s study. (13)

A randomized controlled trial of the effects of home-based aerobic and resistance training counseling on glycemic control in older adults with prediabetes was conducted by Miriam C. Morey et al. Demonstrated a significant improvement in the subjects' fasting blood glucose level (0.33 mmol/l), body mass index (0.61 kg/m2), and QoL domains like physical functioning (0.42%) and general health (3.27%).The current study's findings on COVID-induced new-onset diabetes demonstrated improvements in fasting blood glucose levels (0.34 mmol/l), BMI (4.2 kg/m2), and quality-of-life areas like physical functioning (8.4%) (p = 0.001) and general health (11.95%) (p = 0.001). As compared to Miriam C. Morey et al.'s study, the current study's treatment regimen is shorter but more frequent, and because our population is younger, it showed improvement in HbA1C, fasting blood glucose level, BMI, and SF-36 parameters, which improved patients' health status and increased daily activities and quality of life.(14)

CONCLUSION

Numerous well-designed studies have demonstrated the efficacy of dietary and exercise interventions in improving glycemic control and reducing the incidence of type 2 diabetes among individuals with prediabetes. In light of our study's specific focus on COVID-induced new-onset diabetes, our findings emphasize the crucial role that a structured exercise protocol, combined with lifestyle modifications, can play in improving the quality of life and decelerating the progression of this emerging condition.

To meet the expectations of our academic community and enhance the practical relevance of our study, we should emphasize the implications of our findings for clinical practice and future research. From a clinical perspective, our study underscores the immediate relevance of integrating tailored structured exercise regimens and lifestyle modifications into the management of COVID-induced new-onset diabetes. These interventions can serve as valuable tools for healthcare professionals in mitigating the impact of this condition on patients' well-being.

Moreover, our research opens up promising avenues for further investigation. Future studies may delve deeper into optimizing exercise protocols, refining the customization of lifestyle modifications for distinct patient profiles, and examining the long-term implications of such interventions. Additionally, exploring the underlying mechanisms through which structured exercise and lifestyle changes influence glycemic control in the context of COVID-induced new-onset diabetes could provide crucial insights for the development of targeted therapies and interventions.

In conclusion, our study contributes meaningfully to the existing body of evidence regarding the effectiveness of structured exercise and lifestyle modifications in addressing the challenges posed by COVID-induced new-onset diabetes. By emphasizing the clinical implications and future research opportunities, we aim to ensure that our work aligns with both academic standards and the practical needs of healthcare practitioners..

LIMITATION

The major limitation is that very limited research has addressed the efficacy of structured exercises and lifestyle modifications in COVID-induced new-onset diabetes patients. The number of sample sizes related to this study was low. So, further study with a larger sample size is necessary.

Acknowledgement:

I acknowledge the guidance and constant support of Dr. T Poovishnu Devi, Dean (Academics), HOD department of cardiopulmonary physiotherapy, Karad and Dr Kakade SV and Shri Ram Kulkarni, for help with statistical analysis.

References:

1. Rubino F, Amiel SA, Zimmet P, Alberti G, Bornstein S, Eckel RH, Mingrone G, Boehm B, Cooper ME, Chai Z, Del Prato S. New-onset diabetes in Covid-19. New England Journal of Medicine. 2020 Aug 20;383(8):789-90.https://covid19.who.int
2. Khunti K, Del Prato S, Mathieu C, Kahn SE, Gabbay RA, Buse JB. COVID-19, hyperglycemia, and new-onset diabetes. Diabetes Care. 2021 Dec 1;44(12):2645-55.
3. Valencia I, Peiro C, Lorenzo O, Sanchez-Ferrer CF, Eckel J, Romacho T. DPP4 and ACE2 in diabetes and COVID-19: therapeutic targets for cardiovascular complications? Frontiers in pharmacology. 2020 Aug 7; 11:1161.
4. Steenblock C, Schwarz PE, Ludwig B, Linkermann A, Zimmet P, Kulebyakin K, Tkachuk VA, Markov AG, Lehnert H, De Angelis MH, Rietzsch H. COVID-19 and metabolic disease: mechanisms and clinical management. The lancet Diabetes & endocrinology. 2021 Nov 1;9(11):786-98.
5. Pasin L, Navalesi P, Zangrillo A, Kuzovlev A, Likhvantsev V, Hajjar LA, Fresilli S, Lacerda MV, Landoni G. Corticosteroids for patients with coronavirus disease 2019 (COVID-19) with different disease severity: a meta-analysis of randomized clinical trials. Journal of cardiothoracic and vascular anesthesia. 2021 Feb 1;35(2):578-84.
6. Whillier S. Exercise and insulin resistance. Physical Exercise for Human Health. 2020:137-50.
7. Westcott WL. Resistance training is medicine: effects of strength training on health. Current sports medicine reports. 2012 Jul 1;11(4):209-16.
8. Maiorana A, O'Driscoll G, Goodman C, Taylor R, Green D. Combined aerobic and resistance exercise improves glycemic control and fitness in type 2 diabetes. Diabetes research and clinical practice. 2002 May 1;56(2):115-23.
9. Taylor LM, Spence JC, Raine K, Plotnikoff RC, Vallance JK, Sharma AM. Physical activity and health-related quality of life in individuals with prediabetes. Diabetes research and clinical practice. 2010 Oct 1;90(1):15-21.
10. Bhosale AV, Thangavelu PD. Effect of lifestyle modification in Type II diabetes mellitus individuals. Asian J Pharm Clin Res. 2019;12(2):381-3.
11. Chen X, Zhao S, Hsue C, Dai X, Liu L, Miller JD, Fang Z, Feng J, Huang Y, Wang X, Lou Q. Effects of

aerobic training and resistance training in reducing cardiovascular disease risk for patients with prediabetes: A multi-center randomized controlled trial. Primary Care Diabetes. 2021 Dec 1;15(6):1063-70.

12. Liu Y, Li J, Zhang Z, Tang Y, Chen Z, Wang Z. Effects of exercise intervention on vascular endothelium functions of patients with impaired glucose tolerance during prediabetes mellitus. Experimental and therapeutic medicine. 2013 Jun 1;5(6):1559-65.
13. Morey MC, Pieper CF, Edelman DE, Yancy Jr WS, Green JB, Lum H, Peterson MJ, Sloane R, Cowper PA, Bosworth HB, Huffman KM. Enhanced fitness: a randomized controlled trial of the effects of home-based physical activity counseling on glycemic control in older adults with prediabetes mellitus. Journal of the American Geriatrics Society. 2012 Sep;60(9):1655-62.