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Original Article

Effects of Combined Training Protocol on Glucose Control and Blood Pressure Among Type II Diabetes Mellitus

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ABSTRACT

Background: Diabetes mellitus is a long-term metabolic condition marked by persistent hyperglycemia. It could be caused by a lack of insulin secretion, resistance to insulin's peripheral activities. Type II diabetes is thought to be caused by a combination of genetic and environmental factors. The likelihood of developing type II diabetes rises with age, obesity, and lack of physical activity. **Objective:** To determine the effects of aerobic, resistance and combined exercises in improving biomarkers (HbA1C, plasma glucose and lipid level) and blood pressure after 12 weeks of intervention. **Methods:** A randomised control trial study was conducted on a sample size of 60 patients visiting Baqai Hospital, Karachi. Patients were divided into three groups by using a randomised sampling technique via a lottery method. Patients in Group A were taken as the intervention group underwent aerobic exercise, In Group B as the Resistance group and in Group C as combined or mixed (aerobic and resistance training), Before starting intervention at baseline weight, body mass index, plasma glucose, systolic and diastolic blood pressure, HbA1C, high and low-density lipoproteins and triglycerides of all the participants were measured. After 12 weeks of intervention Readings were repeated. Data was collected by using Performa by the Principal investigator. Frequencies and percentages were calculated for the qualitative variables. Mean and standard deviations were calculated for the quantitative variables. Findings were then stratified and compared among the three groups. Paired t-test was used to see changes in variables post-intervention. A one-way ANOVA test was applied to see statistically significant differences among study groups, keeping p-value≤0.05 as significant. **Results:** Reduction after 12 weeks of intervention was observed among study groups. Post-interventional weight, body mass index, blood plasma glucose, HbA1C, high and low-density lipoproteins and triglycerides varied significantly whereas no change was observed for Systolic and diastolic blood pressure. **Conclusion:** Our study results concluded that aerobic, resistance, and mixed exercise study participants have little to more favourable benefits regarding blood glucose, weight, body mass index, and lipid profile when compared to type II diabetic patients.

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INTRODUCTION

Diabetes mellitus (DM) is a long-term metabolic condition marked by persistent hyperglycemia. It could be caused by a lack of insulin secretion, resistance to insulin's peripheral activities, or both. According to the International Diabetes Federation (IDF), diabetes mellitus affected roughly 415 million persons aged 20 to 79 in 2015. DM is proving to be a global public health problem, with another 200 million people expected to be affected by 2040. (Zheng Y et al., 2018) Type I and II diabetes, and gestational diabetes mellitus (GDM) are the three forms of diabetes based on aetiology and clinical presentation. Monogenic diabetes and secondary diabetes are two less prevalent kinds of diabetes. (Malek R et al., 2019, Choi YJ et al., 2016, Picke AK et al., 2019 and Carrillo-Larco RM et al., 2019) Type 2 diabetes mellitus (T2DM) accounts for almost 90% of all diabetes cases. (Malek R et al., 2019, Choi YJ et al., 2016, Picke AK et al., 2019 and Carrillo-Larco RM et al., 2019) The prevalence of diabetes has increased worldwide because of changing lifestyles and rising obesity rates. In 2017, 425 million people worldwide had diabetes. According to the International Diabetes Federation (IDF), diabetes affected around 10% of the American population in 2015.

Seven million of them went undetected. The prevalence of diabetes rises as people get older. Diabetes affects over a quarter of the population over the age of 65. (Carrillo-Larco RM et al., 2019) After an overnight fast of 8 hours, a blood sample is collected. A fasting plasma glucose (FPG) level of higher than 126 mg/dL (7.0 mm/L) is consistent with the diagnosis, according to the American Diabetes Association. (Goyal R and Jialal I 2021). The plasma glucose level is tested before and two hours after ingesting 75g glucose in this test. If the plasma glucose (PG) level in a 2-hour sample is more than 200 mg/dL (11.1 mmol/L), diabetes is diagnosed. It is a routine test as well, although it is inconvenient and more expensive than FPG, and it has significant variability difficulties. For 3 to 5 days, patients must eat a diet containing at least 150 grammes of carbohydrates per day and avoid taking any medications that can affect glucose tolerance, such as thiazide diuretics and steroids (Goyal R and Jialal I 2021) This test offers you an average of your blood glucose levels over the previous two to three months. Diet and exercise are the cornerstones of treatment for both T1DM and T2DM. (Lai LL et al., 2019, Eckstein ML et al., 2019 and Massey CN et al., 2019) Hb A1C should be less than 7% for the majority of people to avoid microvascular problems.

The target blood pressure should be less than 130/85 mmHg, with angiotensin-converting enzyme (ACE)/angiotensin receptor blocker (ARB) therapy being preferred. Fundal exams and urine albumin excretion should be done at least twice a year, as recommended by guidelines. If no atherosclerotic disease is present, the target for the lipid panel should be an LDL-C of less than 100 mg/dl, or less than 70 mg/dl if ASCVD is present. Statins are the medicine of choice since they lower cardiovascular events and mortality. Patients with ASCVD who are not on target may benefit from ezetimibe and PCSK9 inhibitors. (Shah SR et al., 2019 and Zhonghua et al,.2018) Adopting a sedentary lifestyle results in type II diabetes mellitus (T2DM) prevalence and as a consequence, chances of future complications are increased further worsening the condition. Here is needed to adopt a healthy lifestyle by adding regular exercises in routine practice thus reducing the chances of T2DM as well as preventing its consequences and it is on the rise among our population due to the adoption of certain sedentary lifestyles, adoption of more carbohydrates and less fibre, junk foods etc. so there is a dire need to conduct such study to

formulate a pattern of lifestyle with exercise as an integral part by counselling the patients and telling them about the drawbacks and future consequences they may face as regards to T2DM. In the study by Anna K Jannson et al. in 2021 When comparing RT and aerobic exercise, no significant differences in HbA1C were identified (p=0.42). This study shows that RT is an effective method for lowering HbA1c in people with T2DM. Importantly, RT interventions with a bigger training impact proved to be more effective in lowering HbA1c than those with medium and small effects. The purpose of the study was to determine the effects of aerobic, resistance and combined exercises in improving biomarkers (HbA1C, plasma glucose and lipid level) and blood pressure after 12 weeks of intervention.

METHODS

The duration of this randomized controlled trial was 6 months after approval of the synopsis. The sample size was 20 in each group, keeping $\alpha = 0.05$, a confidence interval of 95%. A probability sampling technique was used (Lottery Method). The study was conducted after approval from the Ethical Review Committee of Ziauddin University. Prior permission from the patients was taken. All information gathered during this study was kept confidential. Both male and female patients having type II diabetes mellitus, attending OPD of Diabetology and Endocrinology, Baqai University Hospital were recruited in the study. Patients attending diabetic clinics and having type II diabetes with a duration of disease of at least one year or more were enrolled on the outpatient Department. Patients having other concomitant illnesses like cardiovascular diseases, respiratory illnesses, other endocrine disorders etc. were excluded. Patients were then divided into three groups by using a randomized sampling technique via a lottery method. Patients in Group A were taken as the intervention group undergoing Aerobic exercise, In Group B as the Resistance group and in Group C as combined or mixed (aerobic and resistance) Before starting intervention at baseline weight, BMI, systolic and diastolic blood pressure, plasma glucose, HbA1c, VLDL, HDL, LDL and triglycerides of all the participants were measured. All subjects continued their medication as per their routine. In addition to medicine Group A was given exercise intervention as a 45-minute session three times a week for 12 weeks whereas no intervention was assigned to the control group.

After 12 weeks of intervention, all the subjects were evaluated for post-intervention weight, BMI, systolic and diastolic blood pressure (SBP, DBP), plasma glucose, HbA1c, VLDL, HDL, LDL, and triglycerides. Any change observed from baseline will be noted and compared from baseline measurements among both groups. Patients were selected by using the probability sampling technique and they will be further divided into three groups by using lottery method, each group with n=20 participants. Group A was given Aerobic exercise as an intervention, Group B resistance group and Group C were given combination therapy. Informed/written consent from the patients was taken before their oral enrollment, examination and their medical history were taken by the principal investigator.

Data was collected through a structured questionnaire having two sections. The first part contained demographic variables and other variables related to Type II diabetes mellitus and other concomitant diseases. In second part contains a chart that shows Pre and Post-intervention measurements of Weight, BMI, systolic and diastolic blood pressure, plasma glucose, HbA1C, VLDL, HDL, LDL, and triglycerides. Adults with diabetes should engage in 2-3 sessions/week

of resistance exercise on nonconsecutive days. The duration of this intervention was 45 minutes. (Warm-up: 15 minutes, free weight exercise: 15 minutes, cool down: 15 minutes), thrice a week lasting for 12 weeks. In this resistance training, patients used the lowest resistance available (i.e.: free weights as resistance exercises). With the aid of free weights patients perform triceps curl, basic push up and lunges with 15 repetitions of an exercise. In the combined training protocol, the patients performed combined exercises (i.e.: cycling and free weights) with 15 repetitions of a resistance exercise along with warm-up and cool-down. The duration of this intervention was a 45-minute session, 3 times a week for 12 weeks.

Frequencies and percentages were calculated for the qualitative variables. Mean and standard deviations were calculated for the quantitative variables. Findings were then stratified and compared among the three groups. The paired t-test was used to see changes in variables post-intervention. A one-way ANOVA test was applied to see statistically significant differences among study groups, keeping p-value ≤ 0.05 as significant.

RESULTS

Table 1 shows the frequency and percentage distribution of age and gender. According to the study, 21.7% of the participants belong to 34-40 and 41-47 years of age groups each, 20.0% of the participants belong to 48-54 and 55-61 years of age groups each and lastly, 16.7% of the participants belong to 62-68 years of age. Male and female participants were equal in number involved in the study. Table 2 shows pre and post-intervention mean ± S.D values of demographic variables for all the study participants and reduction in post-intervention mean ± S.D of Weight, Body Mass Index, Plasma blood glucose, HbA1C, VLDL, LDL and triglyceride was reported from pre-intervention mean and standard deviation whereas there were increased HDL

Table 1: Exercise Training Protocol: Types of Exercises, Intensity and Duration

	Aerobic Training	Resistance Training	Combined Training
Types of Exercise	Patients performed prolonged, rhythmic activities using their large muscle groups through cycling	Patients used the lowest Resistance available (i-e: free weights as resistance exercises	Patients performed combined exercises (i.e., cycling and free weights)
Intensity	Moderate	15 repetitions of an exercise	15 repetitions of resistance exercise and cycling with warm-up and cool-down
Duration	The intervention was implemented through a 45-minute session. (warm-up: 15 minutes, cycling: 15 minutes, cool down: 15 minutes) 3 times a week for 12 weeks	The duration of this intervention was 45 minutes. (warm-up: 15 minutes, free weight exercise: 15 minutes, cool down: 15 minutes), thrice a week lasting for 12 weeks	The intervention duration was a 45-minute session, 3 times a week for 12 weeks

Figure 1: Frequency Distribution of Pre-Intervention Plasma Glucose

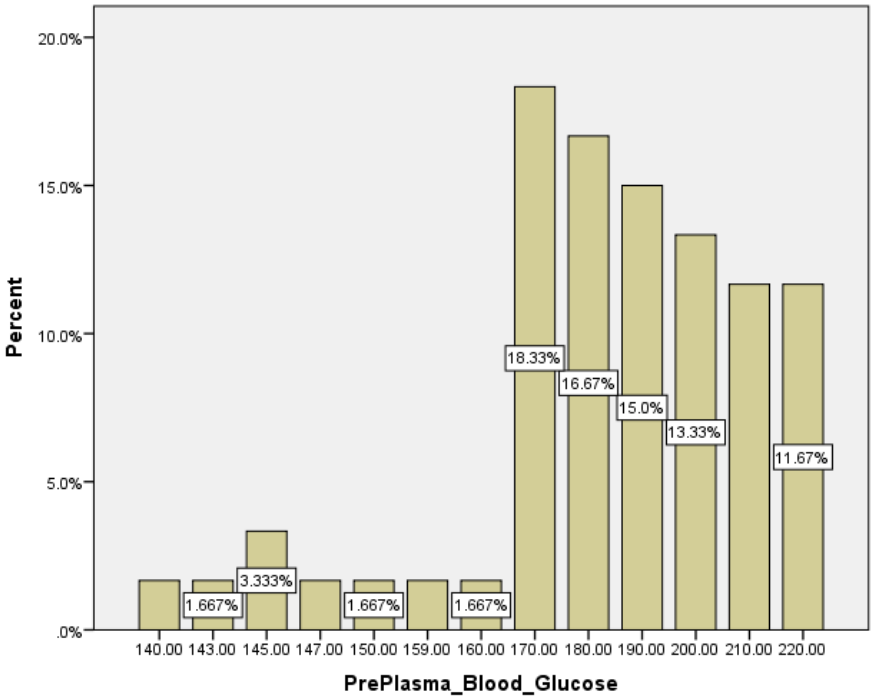
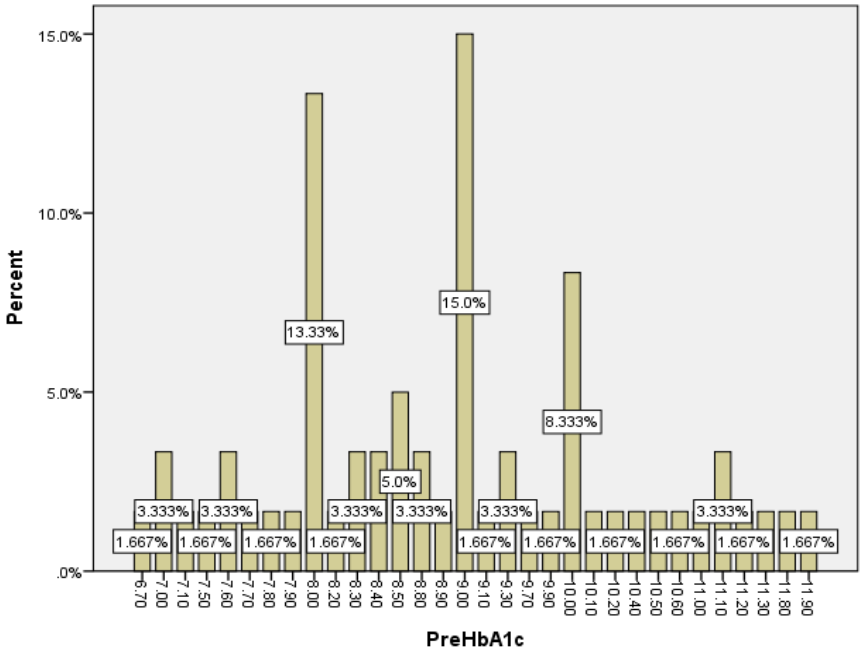


Figure 2: Frequency Distribution of Pre-Intervention HbA1C



levels seen post-intervention. While table 3 shows the pairwise comparison among the aerobic exercise group before and after intervention and it was seen that there is a significant difference in mean values of BMI, plasma glucose, HbA1C, VLDLs, LDLs, triglyceride (p-0.000) and HDLs (p-0.001). No significant difference was seen for SBP and

Table 2: Age and Gender of Participants

Variable (n=60)		Frequency	Percentage %	Mean±SD
Age (years)	34 – 40	13	21.7%	49.68 ± 1.71
	41 – 47	13	21.7%	
	48 – 54	12	20.0%	
	55 – 61	12	20.0%	
	62 - 68	10	16.7%	
Gender	Male	30	50%	
	Female	30	50%	
Total		**60**	**100%**	

Table 3: Baseline Characteristics

Variables	Pre-Intervention Mean±S.D	Post-Intervention Mean±S.D
Weight	76.09 ±1.75	71.33 ± 1.37
BMI	29.08 ±5.133	27.26 ± 4.99
Systolic BP	119.00 ± 1.36	119.70 ± 5.86
Diastolic BP	76.58 ± 5.48	76.50 ± 4.72
Plasma Blood Glucose	186.32 ± 1.99	174.92 ± 1.15
HbA1C	09.02 ± 1.26	07.94 ± 1.26
VLDL	29.85 ± 1.18	27.79 ± 1.26
HDLs	45.59 ± 1.39	52.52 ± 1.88
LDLs	82.68 ± 2.65	73.60 ± 2.81
Triglycerides	147.56 ± 1.37	137.05 ± 1.63

DBP. Table 4 showed that the pairwise comparison among the resistance group before and after intervention and it was seen that a statistically significant difference was observed between pre and post-intervention mean and standard deviation of BMI, plasma glucose, HbA1C, LDLs, HDLs (p-0.000) and triglyceride (p-0.008). No significant difference was seen for VLDL and Blood pressure. Table 6 showed One-way ANOVA

Table 4: Within-Group Analysis of BMI, Blood Pressure, Plasma Blood Glucose, HbA1C and Lipid Profile in Aerobic Group

Variables	Pre-Intervention Mean±SD	Post-Intervention Mean±SD	95% CI	p-value
BMI (kg/m^2)	29.325±5.76	27.545±5.85	1.22 to 2.23	0.00
Systolic BP (mm/hg)	115.5±29.1	119.35±6.88	-16.6 to 8.9	0.538
Diastolic DBP (mm/hg)	76.5±5.40	76.25±5.09	-3.8 to 4.37	0
Plasma Glucose (mg/dl)	197±16.25	184.85±14.78	9.12 to 15.17	0.00
HbA1C (%)	9.1±1.13	8.1±0.96	1.19 to 10.7	0.00
VLDLs (mg/dl)	27.47±10.15	25.55±9.88	1.6 to 2.23	0.00
HDLs (mg/dl)	47.7±24.29	55.15±18.32	-11.63 to-3.26	0.001
LDLs (mg/dl)	80.7±31.15	71.4±26.51	4.87 to 13.7	0.00
Triglycerides (mg/dl)	137.3±50.7	128±49.61	7.72 to 10.87	0.00

Table 5: Within-Group Analysis of BMI, Blood Pressure, Plasma Blood Glucose, HbA1C and Lipid Profile in Resistance Group

Variables	Pre-Intervention Mean±SD	Post-Intervention Mean±SD	95% CI	p-value
BMI (kg/m^2)	28.935±4.62	26.965±4.46	1.5 to 2.36	0.00
Systolic BP (mm/hg)	119±7.88	119.75±6.17	-5.3 to 3.8	0.735
Diastolic BP (mm/hg)	76.25±5.34	76.75±4.37	-4.5 to 3.58	0.8
Plasma Glucose (mg/dl)	186.15±18.37	174.75±18.43	14.2 to 8.3	0.00
HbA1C (%)	9.27±1.54	8.115±1.68	0.98 to 1.32	0.00
VLDLs (mg/dl)	33.45±7.93	30.87±11.36	-0.9 to 6.06	0.137
HDLs (mg/dl)	43.91±8.08	50.51±6.29	-8.7 to -4.4	0.00
LDLs (mg/dl)	80.85±22.12	72.6±20.92	6.2 to 10.2	0.00
Triglycerides (mg/dl)	167.25±39.69	148.35±45.93	5.42 to 32.3	0.008

Table 6: Association of Variables Pre and Post-intervention

Variables	Study Groups	Pre-Intervention Mean±S.D	p-value	Post-Intervention Mean±S.D	p-value
BMI	Group A	29.32±5.76	0.968	27.54±5.85	0.937
	Group B	28.93±4.62		26.96±4.46	
	Group C	28.99±5.2		27.28±4.79	
Systolic BP	Group A	115.5±2.1	0.491	119.35±6.88	0.941
	Group B	119.0±1.88		119.75±6.17	
	Group C	122.5±1.57		120±4.58	
Diastolic BP	Group A	76.5±5.4	0.910	76.25±5.09	0.947
	Group B	76.25±5.34		76.75±4.37	
	Group C	77.0±5.93		76.5±4.89	
Plasma Blood Glucose	Group A	197.0±1.25	0.008*	184.85±1.78	0.011*
	Group B	186.15±1.37		174.75±1.43	
	Group C	175.8±2.77		165.15±5.03	
HbA1C	Group A	9.1±1.13	0.318	8.1±0.96	0.346
	Group B	9.27±1.54		8.11±1.68	
	Group C	8.68±1.02		7.6±0.99	
VLDLs	Group A	27.47±10.15	0.47	25.55±9.88	0.171
	Group B	33.45±1.93		30.87±11.36	
	Group C	28.63±1.52		26.96±4.83	
HDLs	Group A	47.7±2.29	0.763	55.15±1.32	0.513
	Group B	43.91±1.08		50.51±6.29	
	Group C	45.15±1.06		51.9±11.33	
LDLs	Group A	80.7±1.15	0.758	71.4±26.51	0.776
	Group B	80.85±2.12		72.6±20.93	
	Group C	86.5±2.85		76.8±27.45	
Triglycerides	Group A	137.3±5.76	0.031*	128±49.6	0.295
	Group B	167.25±3.69		148.35±45.93	
	Group C	138.15±2.46		134.8±24.17	

results as it was performed to see an association between variables among different groups and it was seen that there was statistically a significant difference between plasma blood glucose and triglyceride with p-value 0.008 and 0.031 respectively, among different study groups. For post-interventional variables, there was a significant difference in plasma blood glucose levels among study groups (p-0.011).

DISCUSSION

In light of previous studies, it can be seen that resistance, aerobic, and combined exercise have small to moderate favourable benefits on glucose control in type 2 diabetic patients, as well as weight BMI and lipid profiles are also improved after intervention. Furthermore, there is evidence that combined aerobic and resistance exercise has additional benefits in insulin resistance and blood glucose levels. (Zeinab Amini Lari et al., 2017) Our study results showed a reduction in pre and post-intervention Weight, BMI, blood plasma glucose, HbA1C, VLDLs, HDLs, LDLs and triglyceride. Our study showed a reduction in pre and post-intervention weight, and BMI whereas dissimilar findings were observed by Our study results showed a reduction in pre and post-intervention blood plasma glucose and HbA1C Like the present study previous study by Zeinab Amini Lari et al., in 2017 reported Blood plasma glucose reduction in both intervention they also found that all three workout types resulted in significant but minor reductions in HbA1C. The majority of the benefits were positive and of small to moderate magnitude for all other measures of glucose control (fasting glucose, postprandial glucose, insulin sensitivity, and fasting insulin). Riddell and Peters, in 2023 also provided evidence that exercises especially resistance exercises were effective in improving blood glucose and HBA1C in diabetic patients. Xing et al., in 2022 also compared aerobic and resistance exercises and results showed that both were effective in improving outcomes in diabetic population (p=<0.05).

Dissimilar findings were reported by Anna K. Jannson et al., 2021 they found no statistically significant differences in HbA1C values among study groups comparing (resistance and aerobic training) (p=0.42).

CONCLUSION

Our study results concluded that that aerobic, resistance, and mixed exercise study participants have little to more favourable benefits regarding blood glucose, weight, BMI, and lipid profile when compared in type 2 diabetic patients.

DECLARATIONS

Consent to participate: Written consent had been taken from patients. All methods were performed following the relevant guidelines and regulations.

Availability of data and materials: Data will be available on request. The corresponding author will submit all dataset files.

Competing interests: None

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Authors' contributions: All authors read and approved the final manuscript.

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