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Impact of Lifestyle Interventions on Glucose and Lipid Profile Among Type 2 Diabetes mellitus Patients: A Longitudinal Study

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Abstract

Type 2 diabetes mellitus is one of the most deadly, disabling and costly disease facing the world and it continues to be on the rise at epidemic proportions. Type 2 Diabetes mellitus and dyslipidaemia are metabolic disorders that significantly increase the risk of cardiovascular diseases.

The present study aims to explore the effect of lifestyle modifications on the levels of biochemical variables as well as categorization by changes in diet, physical activity, both or no modification at all among individuals suffering from type 2 diabetes mellitus.

A total of 680 diabetic patients were evaluated for glucose, serum triglycerides, total cholesterol, LDL, HDL and VLDL levels, who were then grouped according to their voluntary compliance levels into four groups (first with diet as modification, second with exercise as modification, third with both diet and exercise as modification and the fourth one with no modification at all). The variables were assessed at baseline, further followed up longitudinally after every three months interval for next 12 months (i.e. five times in the course of the present study) and the levels of different variables of lipid profile were categorized after every follow-up.

It was observed that glucose and lipid profile variables had significantly reduced levels after adoption of lifestyle modification programme in every follow-up. The categorization of lipid profile parameters illustrated that the lifestyle modifications were able to increase the number of individuals in normal categories, reducing the numbers in risk categories.

Among the four groups, it can be further elucidated that exercise was an effective measure in lowering the levels of all biochemical parameters in comparison to other modification groups.

Key words : Dietary, lipid profile, modification, type 2 diabetes.

Diabetes mellitus is a chronic condition characterized by hyperglycemia due to absolute or relative deficiency of insulin. It is a metabolic disorder in which the individuals either have a shortage of insulin or decreased ability to utilize insulin. It is usually irreversible and patients can lead a reasonably normal life. There are three types of diabetes, type 1, type 2 and gestational diabetes[13]. Presently, type 2 diabetes mellitus is one of the most deadly, disabling and costly disease facing the world and it continues to be on the rise at epidemic proportions. Type 2 Diabetes mellitus and dyslipidaemia are metabolic disorders that significantly increase the risk of cardiovascular diseases. Elevated triglycerides (TG) and poor glycemic control have been observed in individuals with diabetes, contributing to higher morbidity and mortality rates[2,30]. The International Diabetes Federation[14] reported that there were 589 million adults (20 – 79 years) with diabetes in 2024, representing 11.1% of world's population in this age group, alarmingly increasing to 853 million by 2050 (representing 13% of the population) with more of undiagnosed cases, because of urbanization, aging, unbalanced diet, obesity and sedentary lifestyles, thereby resulting into a global health emergency. In Asian countries, it is disproportionately higher in young to middle aged adults. This could have long lasting adverse effects on the Nation's health and economy, especially for developing countries[14,22].

The prevention of even a small proportion of cases would save thousands of lives and billions of money spent in health care costs. Researchers have made great strides in identifying many lifestyle and dietary factors associated with diabetes, but solidifying the scientific basis for prevention and control of this disease as well as implementation at national level remains a difficult challenge. Lifestyle modifications are the most cost effective intervention for prevention and control of diabetes in high-risk groups in India[6] and evidences suggest that healthy lifestyle choices such as adequate weight loss, nutritious diet and regular exercise can help manage the disease. They must target not only the affected individuals but also families, workplaces and communities. There is lack of awareness about the role of lifestyle changes among diabetic people. Unfortunately, people suffering from diabetes are not aware about the lifestyle interventions namely nutrition and exercise, which are the cover stones of the successful diabetes control and prevention therapies.

Epidemiological studies have reported that lifestyle changes with diet and physical activity can prevent development of type-2 diabetes[3,16,18,20,27,29,32,33]. Haslett *et al.,*[13] and Expert Committee on the Diagnosis and Classification of Diabetes Mellitus : American Diabetes Association[2] observed that diet and physical activity as a part of lifestyle modification would reduce weight and trunkal fat, while Knowler *et al.*[18] concluded that the incidence of diabetes reduced by 58% with lifestyle intervention[8,13,18]. The American Diabetes Association (2024) and several clinical studies[2] have emphasized that lifestyle interventions play a crucial role in improving the metabolic parameters in the individuals suffering with diabetes. But methodological constraints particularly the large populations and long-follow ups required, partly explain the

lack of outcome studies in diabetes[1,4,6,7,9,11,16,19,21,24,25,31,33].

The present study was designed to assess the effectiveness of a low-resource intensive lifestyle modification by reorientation of diet and exercise programme among individuals suffering from type 2 diabetes mellitus and to compare the practical strategies for assisting patients in achieving lifestyle changes to help manage the disease.

The study population comprised of patients aged 40 to 50 years and diagnosed with type-2 diabetes mellitus more than three years back. Initially 400 males and 400 females (100 in each group with lifestyle modification) were recruited in the study. But by the end of four follow ups, there were 85 individuals left in each of the 4 groups of both the sexes whose compliance levels were up to the mark. Therefore, the results have been compiled for 680 subjects (340 male and 340 females). The pretested, pre-designed questionnaire was used to assess the sociodemographic characteristics, lifestyle and dietary habits, monitoring of blood glucose, drug compliance, eye examination and foot care. The study was undertaken with participants who voluntarily accepted and gave their written consent to adhere to the lifestyle intervention and agreed to come in contact for regular follow-ups. The intervention included a two week group self-management education programme and then grouping them according to their voluntary compliance levels into four groups (first with diet as modification, second with exercise as modification, third with both diet and exercise as modification and the fourth one with no modification at all). Fasting plasma glucose, blood lipids, physical activity and diet were assessed at baseline and same was followed up longitudinally after every three months interval for next 12 months (*i.e.* five times in the course of study). All the subjects were briefed about the project and their consent was taken. The confidentiality of the subjects was maintained and all the guidelines as given by Indian Council of Medical Research were followed. The study was funded as Major Research Project by University Grant Commission (UGC), New Delhi, and approved by Institutional Clinical Ethical Committee (ICEC/36/2012). The data were collected from different areas of Punjab. The blood sample was withdrawn by a trained technician and the biochemical analysis was performed in the laboratory of the department. The levels of different variables of lipid profile were categorized according to the criteria given by National Cholesterol Program NCEP ATP III (2002)[28]. Chi-square test and t-test were used to compare the data.

The different variables were analyzed in the four groups (group one with diet, group two with exercise, group three with both diet and exercise and group four with no modifications at all) from initial evaluation to the fourth follow-up. The paired t-test analysis was performed to compare the levels of glucose and variables of lipid profile (Table-1) in subjects suffering from Diabetes mellitus at the initial stage and at the end of the study (involving four follow-ups post intervention) in all the groups. In group one, the levels of glucose and variables of lipid profile decreased at all the follow-ups, but the differences were statistically non-significant. In group two, the levels of glucose, TC, LDL, HDL, TG and VLDL decreased by 8.54%, 6.79%, 7.24%, 5.07%, 8.31% and 8.32% respectively from

initial evaluation to the fourth follow-up. There was a statistically significant differentiation in glucose ($t=1.98$, $p< 0.05$), total cholesterol ($t=2.63$, $p< 0.05$) and LDL ($t= 2.54$, $p<0.05$) levels at the start and end of fourth follow-up in exercise lifestyle modification group. Among the Group three subjects, the levels of biochemical parameters reduced significantly *i.e.* by 10.9% for glucose, 4.63% for total cholesterol, 4.67% for LDL, 4.5% for HDL, 5.71% for triglycerides and 5.71% for VLDL from initial value to the fourth follow-up. In group four, the levels of glucose and HDL decreased during the progression of the study. But the revealing effect was that the levels of total cholesterol, LDL, triglycerides and VLDL increased since the subjects of this group continued their earlier regime.

Upon the assessment of total cholesterol levels, it can be elaborated that the number of patients suffering from diabetes mellitus under various categories changed remarkably in all the four studied groups. By the end of the fourth follow-up, the number of subjects with normal total cholesterol levels increased in all the intervention groups except the groups with only dietary changes and no modification at all (Table-2a). The subjects with borderline values increased due to the interventional changes in all the groups except in the ones with no lifestyle modification. The percentage of the subjects in the high risk category decreased from 57.6% to 31.3% in group two and from 35.9% to 26.5% in the group three. It can be concluded that only exercise and combined intervention of diet and exercise together were important in lowering the cholesterol levels and thereby decreasing the number of subjects with high risk due to elevated cholesterol levels. The differences in all the four groups were statistically significant.

According to HDL levels categorization, there is reduction in the number of individuals in high risk category in group one (85 to 71) and group three (44 to 30) (Table 2a) during the progression of four follow-ups. The number of individuals having normal levels decreased and the percentage of subjects with borderline and high risk values increased in the last group which had no lifestyle modification. It can be elucidated further that exercise modification (group 2) was a better option in reducing HDL levels and the number of high risk subjects among all the studied groups. The percentage of individuals increased in the last group which had no lifestyle modification during the course of the study.

For low density lipoprotein (LDL) levels, the percentage of individuals in the very high risk category decreased from 39.4% to 22.4% in group two and from 28.2% to 24.1% in group three (Table-2b). This is more pronounced in a group two which had exercise as the lifestyle modification. While the numbers drastically increased in the high risk and very high risk categories among the subjects of no modification group (group four).

The categorization on the basis of triglycerides elucidated that the number of subjects with normal levels of triglycerides increased in the subjects of modification groups, except in the no modification group patients (Table-2a). The number of subjects with borderline levels increased in the group two (with exercise). There was a decrease in the percentage of subjects in the high risk category from first evaluation to the fourth follow-up. The decrease was from 50% to

Table-1. Comparison of levels of glucose and variables of lipid profile from initial assessment to fourth follow-up among subjects of 4 lifestyle modification groups

Variables (mg/dl)	Group 1			Group 2			Group 3			Group 4		
	Pre Follo-wup	Post Follo-wup	t-value	Pre Follo-wup	Post Follo-wup	t-value	Pre Follo-wup	Post Follo-wup	t-value	Pre Follo-wup	Post Follo wup	t-value
Glucose	290.96	284.80	1.05	230.11	210.46	1.98*	216.09	194.27	2.08*	192.39	178.74	1.45
Total chol-esterol	241.83	233.95	1.34	230.47	214.82	2.63*	215.87	205.86	1.44	215.43	221.92	0.55
LDL	175.58	168.01	1.32	176.80	163.88	2.54*	165.01	157.30	1.10	162.10	172.16	0.81
HDL	66.24	65.94	0.42	53.66	50.94	1.49	50.85	48.56	1.35	53.32	49.75	1.91
VLDL	41.45	40.77	0.35	37.75	34.61	1.91	36.40	34.32	1.39	35.05	35.91	0.42
Triglyceride	207.30	203.90	0.36	188.75	173.06	1.91	182.04	171.61	1.39	175.28	179.56	0.43

*Significant at the pd≤0.05 level

(Group1- Diet as modification; Group 2- Exercise as modification; Group 3- Diet and Exercise; Group 4- No modification)

Table-2a. Categorization of subjects on the basis of lipid profile in the four modification groups

Variable	Time of assessment	Normal	Borderline	High risk	p value
Total Cholesterol					
Group 1	Initial	92	14	64	0.0086*
	Fourth follow-up	78	28	64	
Group 2	Initial	52	20	98	0.0001*
	Fourth follow-up	75	42	53	
Group 3	Initial	82	27	61	0.0123*
	Fourth follow-up	88	37	45	
Group 4	Initial	87	44	39	0.2246
	Fourth follow-up	82	39	49	
High-density lipoprotein (HDL)					
Group 1	Initial	14	71	85	0.0003*
	Fourth follow-up	35	64	71	
Group 2	Initial	30	55	85	0.0001*
	Fourth follow-up	51	72	47	
Group 3	Initial	51	75	44	0.0166*
	Fourth follow-up	60	80	30	
Group 4	Initial	63	73	34	0.0001*
	Fourth follow-up	39	82	49	

Triglycerides					
Group 1	Initial	50	28	92	0.2026
	Fourth follow-up	57	21	92	
Group 2	Initial	39	30	101	0.0001*
	Fourth follow-up	54	45	71	
Group 3	Initial	78	24	68	0.1032
	Fourth follow-up	88	27	55	
Group 4	Initial	74	48	48	0.0001*
	Fourth follow-up	70	30	70	
Very Low-density lipoprotein (VLDL)					
Group 1	Initial	43	28	99	1.0000
	Fourth follow-up	43	28	99	
Group 2	Initial	19	16	135	0.0001*
	Fourth follow-up	61	22	87	
Group 3	Initial	58	27	85	0.2461
	Fourth follow-up	68	27	75	
Group 4	Initial	73	34	63	0.0021*
	Fourth follow-up	53	34	83	

*Significant at the p≤0.05 level

(Group1- Diet as modification; Group 2- Exercise as modification; Group 3- Diet and Exercise; Group 4- No modification)

Table-2b. Categorization of subjects on the basis of LDL in the four modification groups

Variable	Time of assessment	Optimal	Sub optimal	Borde-rline	High risk	Very High	p value
Low-density lipoprotein (LDL)							
Group 1	Initial	28	28	43	28	43	0.0494*
	Fourth follow-up	35	22	35	22	56	
Group 2	Initial	10	25	25	43	67	0.0001*
	Fourth follow-up	13	45	42	32	38	
Group 3	Initial	34	17	34	37	48	0.2684
	Fourth follow-up	31	27	34	37	41	
Group 4	Initial	29	29	48	16	48	0.0001*
	Fourth follow-up	39	24	16	19	72	

*Significant at the p≤0.05 level

(Group1- Diet as modification; Group 2- Exercise as modification; Group 3- Diet and Exercise; Group 4 -
No modification)

27.6% in group two and 25.8% to 22.4% in group three. An increase in numbers was observed in group four. The changes due to modifications in all the groups were statistically significant. The scenario depicted that exercise (group 2) was in a way better in reducing TG levels among all the studied groups.

According to categorization on the basis of VLDL levels (Table-2a), it was observed that the number of studied subjects with normal levels increased in group two and three from initial to the fourth follow-up. The percentages of diabetic individuals in the high risk category decreased from 79.4% to 51.2% and 50 to 44.1% in group two and three respectively, while an increasing trend was found in group four.

Although lifestyle modifications have been considered to be important in diabetes mellitus patients, there are few studies concerning their direct effect on the patients with type 2 diabetes mellitus. Several studies have provided strong evidence that structured lifestyle interventions, such as dietary changes and increased physical activity result in significant improvements in metabolic parameters[18,25,32].

The results of the present study are in conformity with earlier investigations which have supported the effectiveness of lifestyle modifications with significant reductions in the levels of total cholesterol, LDL[2,3,6,7,9,10,19,15,25], triglycerides[3,6,7] and glucose[15,16,23,28]. Boyer *et al.* (2018) also concluded that a 1-year lifestyle programme positively impacted HDL quantity in individuals with dyslipidemia[5].

Michishita *et al*.[24] observed that after 12 weeks of intervention the LDL and triglyceride levels decreased but non-significantly in both the exercise training and the diet groups which is in agreement with the present day results[24].

The results in the present scenario reported that exercise was an effective measure in reduction of lipid profile levels which were in compliance with earlier studies[1,12,19,25]. While non-significant differences were observed among individuals with only exercise as the lifestyle modification by Sanghani *et al.*[31] and Kuhle *et al*.[21]. King *et al.*[17] also concluded that exercise was an effective measure in reduction of glucose levels, in agreement with the present study[17,21,31].

Further Yalin *et al.*[33], Gerstel *et al*.[5] and Mandloi *et al*.[23] reported that the subjects in the exercise-diet group showed a statistically significant reduction in total cholesterol, LDL and triglyceride levels. The change in HDL values was statistically non-significant. Pandey (2025) reported statistically decreased glucose levels in diabetic subjects after diet and exercise modifications together[9,23,28,33].

Assessment and categorization of lipid profile parameters has very clearly shown that the lifestyle modifications were able to increase the number of individuals in normal categories, thereby decreasing the numbers in high risk categories among all the modification groups. The greatest transformation was visible in the group two, which highlights the inevitable change that can be brought about by choosing exercise as an intervention. The hypothesis of the present work that lifestyle interventions play a strategic role in lowering the levels of glucose and lipid profile variables

has been proved to true.

In conclusion, it can be elaborated that a statistically significant decreasing trend was observed in different variables after adoption of lifestyle modification programme but longer duration programmes were required to be designed to help the masses. The present study underscores the importance of patient education and adherence to lifestyle modifications as a primary strategy for managing metabolic disorders. Studies should provide an insight towards long term effects and potential genetic and behavioral effects due to lifestyle modifications. The success rate in achieving normal levels of glucose and lipid profile parameters during follow-ups was promising but it continues to be challenging.

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Ethical Considerations

The proposal was approved by Institutional Clinical Ethical Committee (ICEC/ 36/2012).

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Conflicting Interest (If present, give more details):

Author declares that there is no conflict of interest.

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