EFFECTIVENESS OF A DIABETES EDUCATION AND INTERVENTION PROGRAM ON BLOOD GLUCOSE CONTROL FOR PATIENTS WITH TYPE 2 DIABETES IN A TURKISH COMMUNITY

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Abstract. This study was undertaken to determine the effects of patient education and other interventions (regular exercise and diet), combined with existing oral antidiabetic therapy, on blood glucose control in patients with type 2 diabetes mellitus (DM). Two out of 16 primary health care centers present in Elazig, an eastern Turkish city, were randomly selected for this study; the patients had type 2 DM, lived in the service area of these health centers. Of a total of 100 participants, 33 were instructed to follow the standard diet for type 2 DM patients, 28 performed exercise in addition to the standard diet, and 39 did not participate in either exercise or follow the diabetic diet; they served as the control group. The percentage of glycosylated hemoglobin (HbA_{1C}) was measured before and after the 8-week program and comparisons between the groups were made. At the beginning of the program, the HbA_{1C} percentage in the diet-plus-exercise group (9.9±2.6%) was higher than in the diet (7.8±2.2%) and control groups (7.5±2.1%). After the intervention program, the HbA_{1C} value of the control group had not changed significantly, while the most dramatic change in this value was obtained in the diet + exercise group, which was significantly reduced to 7.9±1.5%. The results of this 8-week intervention program indicate that a diabetes education and intervention program involving the combination of exercise and diet enhanced the effectiveness oral therapy on blood glucose control in patients with type 2 DM.

INTRODUCTION

Diabetes mellitus (DM) is one of the most common endocrinological diseases of the world. There are more than 135 million diabetics in the world at present and with the incidence of this disease increasing, this number is expected to exceed 300 million by 2025, with the majority of people having type 2 DM. The aging of population, unhealthy nutrition, obesity, and a sedentary life style are among to the leading causes for this increase (Bethesda, 1996). According to a survey performed in 1997 by National Diabetes Epidemiology for Turkey which involved 24,788 subjects from 15 different cities; 7.2% of the population over 20 years old has DM and 6.7% has impaired glucose tolerance (Satman *et al*, 2002).

Achieving and maintaining glucose concentrations as near to normal as possible by tight glycemic control is absolutely essential for the delay and/or prevention of diabetic complications, as well as for improving the length and quality of life of diabetic patients (Clark *et al*, 2000; American Diabetes Association, 2002).

Weight reduction with calorie restricted diets and increased physical activity are the first line therapy of DM. This will help to control insulin resistance and reduce the metabolic risk factors. This non-pharmacological approach is reported to be affective in only 20% of the patients with type 2 diabetes (Bethesda, 1996). If life style changes involving the diet and exercise are not sufficient to keep blood glucose levels within the normal range, oral antidiabetic medications are tried next. Lifestyle changes delay the need for

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combined therapy and insulin injection, which presents a considerable risk of side effects in these patients (The Diabetes Control and Complications Trial Research Group, 1993).

Since the two recent important large-scale research studies, the Diabetes Control and Complications Trial (DCCT) study and the UK Prospective Diabetes Study (UKPDS), showed conclusively that good glycemic control can delay or prevent microvascular complications, retinopathy, renal failure, and neuropathy, the following therapeutic goals for glycemic control is set by the American Diabetes Association (ADA) have been widely accepted. These include a target of 7% for the HbA_{1C}; 80-120 mg/dl (4.4-6.6 mmol/l) for the fasting plasma glucose (FPG); and 100-180 mg/dl (5.5-10 mmol/l) for a postprandial glucose (ADA, 2001).

HbA_{1C} is a measure of blood glucose control that provides information about average glucose levels over the previous two months. The process of conversion from hemoglobin A to hemoglobin A1c depends on the blood glucose concentration. It provides a much better indication of glycemic control than blood or urinary glucose levels (Kesson *et al,* 1982; Peters *et al,* 1996). Effective treatment will prevent the development of microvascular complications and risk of cardiovascular diseases, which are the leading cause of death in diabetic patients (Stamler *et al,* 1993; Gilmer *et al,* 1997). The strong correlation between obesity and the risk of diabetes development, and the contribution of excessive body fat to glucose intolerance are among to the factors that underline the importance of diet and exercise in the treatment of diabetes (Pennington, 1963).

The effect of diet and/or exercise on the regulation of blood glucose in diabetic patients has been shown in several small and large-scale studies. Lower socioeconomic status and limited access to health care are among the factors that significantly contribute to the higher incidence of diabetes complications. As in many developing countries, continuity of care and education about self-management strategies for most patients with type 2 diabetes in Turkey is provided by primary health care centers. Because there are too many patients to be treated and many still waiting for experienced professionals, health personal in these hospitals do not have enough time to provide education, advice, ongoing support, assessment of the success of given therapy for patients with type 2 diabetes.

This intervention program was carried out to determine the effectiveness of lifestyle changes involving diet and exercise on efficiency of oral antidiabetic therapy in patients with type 2 DM in primary health care setting in an eastern Turkish city.

MATERIALS AND METHODS

The protocol of this study was approved by the local Ethics Committee.

Two out of sixteen primary health care centers present in the Elazig city center, in Turkey, were randomly selected for involvement in this study. Diabetes mellitus patients who live in the service area of these primary health care centers were invited to the heath centers and enrolled in a diabetes education program to promote awareness of the risk factors in diabetes and provide information about the importance of the diet and/or exercise in the management of DM. They were also given patient information brochures on diabetes management.

A multiple-choice questionnaire was filled out to assess the demographic characteristics and information about the health of the patients, how long they have been diabetic, the history of diabetes in the family, the presence of any other chronic diseases, current drug therapy for their diabetes, use of any other drugs, and any adopted life style changes for the non-pharmacological management of DM. Patients were informed of the protocol of this study, and written consent was obtained. Type 2 DM patients, who did not responded to this call and participated in the initial education program, who had other chronic diseases such as hypertension or renal disease were not included in this study. All the other type 2 DM patients who were on oral antidiabetic therapy, without any diabetic diet or regular exercise program, were considered for this study. They were examined at the out-patient clinic for blood pressure, body weight, blood glucose levels, HbA_{1C}, and creatinine clearance. Body mass index (BMI) was determined and ophthalmologi-

cal examination was also performed.

Of the patients with poor diabetes control (indicated by higher percentages of HbA_{1C}), 28 were asked to participate in the diet-plus-exercise intervention group. Thirty-three of the DM patients did not want to participate in the regular exercise program. They were instructed in a standard diabetic diet (mean age 53.1±11.71 y). Thirty-nine age-matched patients with better blood glucose control did not participate in either the exercise or the diet, and served as the control group.

Patients assigned to the diet-plus-exercise intervention group were provided with nutrition counseling as well as brochures about exercise and diet guidelines. They were regularly followed by frequent meetings. Fifteen patients performed regular exercise at the Firat Health Center, Department of Physical Medicine and Rehabilitation, twice a week for 8 weeks, while the remaining 13 patients in this group participated in a walking program, three times a week for 8 weeks. All the exercises were performed 2 hours after the main meal.

At the end of the 8-week intervention program, patients from all groups were re-evaluated with respect to the percentage of HbA_{1C} and BMI, and comparison between the groups was performed.

All the results are given as means ± standard deviation. Statistical analysis was performed using the Student's *t* test, Kruskal Wallis variance analysis, Wann-Whitney *U* test, Wilcoxon rank test and oneway anova where appropriate. A $p<0.05$ was considered significant. Analyses were performed by using SPSS 9.0 for windows.

RESULTS

The intended dietary goals were reached in both groups. The mean ages of the patients were 53.1±11.71 y, 53.1±11.19 y, and 52.6±12.51y in

Table 1
Distribution of general characteristics of the patients according to the groups.

General characteristics	DE group		D group		Control group		Total		p-value
	N	%	N	%	N	%	N	%	
Gender									
Female	17	60.7	21	63.6	27	69.2	65	64.5	NS[a]
Male	11	39.3	12	36.4	12	30.8	35	35.5	
Level of education*									
Illiterate	9	32.1	12	36.4	14	35.9	35	34.8	NS[a]
Literate	4	14.3	1	3.0	5	12.8	10	10.1	
Primary school graduate	11	39.3	15	45.5	15	38.5	41	41.1	
College graduate	3	10.7	4	12.1	4	10.3	11	11.0	
High school graduate	1	3.6	1	3.0	1	2.6	3		
History of DM in the family	14	50.0	17	51.5	17	43.6	48	3.0	NS[a]
Diabetes treatment modality **									
Regular oral agent	18	64.3	18	54.5	27	69.2	63	62.7	NS[a]
Irregular oral agent	9	32.1	11	33.3	10	25.6	30	30.4	
Not using any antidiabetic drug	1	3.6	4	12.1	2	5.1	7	6.9	
Duration of diabetes (month)	91.6±71.5[c]		59.1±68.2[d]		40.7±68.9[e]				p=0.0001[b]

[a]Chi-square test; [b] Oneway anova;
Multiple comparisons with Benferroni: [c]DE and Control groups, $p<0.05$; [d]DE and D groups, $p>0.05$; [e]D and Control groups, $p>0.05$.
DE: diet+exercise group, DM : diabetes mellitus.
*χ^2 test was performed by considering: illiterate patients; literate, but not having graduated from any school; primary school graduates; college and higher levels, regarded as different groups.
**χ^2 test was performed by considering: those not on anti-diabetic drug therapy, those on therapy but not taking drugs regularly and those regularly taking drug therapy, as different groups.

Table 2
Body mass index (BMI, kg/m^2) and HbA_{1C} (%) values of groups before and after the 8-weeks intervention program.

	DE group Mean±SD	Diet group Mean±SD	Control group Mean±SD	p-value[a]
Initial BMI	29.14 ± 4.21	29.39 ± 5.24	29.05 ± 5.28	NS[a]
BMI after IP	27.14 ± 3.86	28.24 ± 5.27	29.35 ± 5.52	NS[a]
HbA_{1C} before IP	9.97 ± 2.64[b]	7.85 ± 2.25[c]	7.51 ± 2.16[d]	p=0.001[a]
HbA_{1C} after IP	7.91 ± 1.52	7.05 ± 1.77	7.59 ± 1.81	NS[a]

[a]Kruskal-Wallis analysis of variance; [b]Mann-Whitney *U* Test: separate comparison between DE and D groups, p<0.05; [c]Mann-Whitney *U* test:separate comparison between DE and control groups, p<0.05; [d]Mann-Whitney *U* test: separate comparison between D and control groups, p>0.05; IP: intervention program; DE: diet + exercise

Table 3
BMI (kg/m^2) and HbA_{1C} (%) values for groups before and after the 8-week intervention program.

	Initial BMI Mean±SD	BM after IP Mean±SD	p-value	Initial HbA_{1C} Mean±SD	HbA_{1C} after IP Mean±SD	p-value[a]
Diet + Exercise group	29.1±4.2	27.1±3.8	p=0.001	9.9±2.6	7.9±1.5	p=0.001
Diet group	29.4±5.2	28.2±5.3	p=0.001	7.8±2.2	7.1±1.7	p=0.001
Control group	29.0±5.3	29.3±5.5	p=0.001	7.5±2.2	7.6±1.8	p=0.21

[a]Wilcoxon rank test; IP: intervention program

the diet, diet-plus-exercise, and control groups, respectively (p=0.84). Table 1 presents each group's information regarding sex, educational level, and family history of DM, and antidiabetic oral therapy. The mean duration for the length of diabetes were 59.09±68.20, 91.64±71.49, and 40.76±68.96 months, for the diet, diet-plus-exercise, and control groups, respectively (p=0.0001, Table 1).

There was no significant difference between the groups with respect to the initial BMI (p=0.90). After the intervention, the BMI values of the diet and diet-plus-exercise groups decreased slightly but these were not statistically significant (p=0.16, Table 2).

The initial HbA_{1C} percentages of patients in diet-plus-exercise group were significantly higher than the diet group and the control group (p=0.001). After the 8-week intervention program, HbA_{1C} percentages for this group were reduced significantly, and were no longer significantly different from the other groups (p=0.11, Table 2).

The BMI and HbA_{1C} values for the groups are given in Table 3.

DISCUSSION

This 8-week intervention program involving the lifestyle changes of diet and diet-plus-exercise in addition to oral anti-diabetic treatment, resulted in better glycemic control.

Several studies have established that the prevalence of type 2 diabetes increases with age (Pennington, 1963; Cruickshank, 1997). Since there was no significant difference between the groups with respect to the mean ages of the subjects involved, the differences in effectiveness between the different groups could not be due to age differences. The groups were also comparable in respect to sex, educational level, family history of DM, and oral antidiabetic drug use, except for the mean duration of DM. The mean duration of DM was significantly longer in the diet-plus-exercise group compared with the control and diet only groups.

The mean BMI values for all the patients involved in this study were 29.19±4.94 kg/m^2 and 28.37±5.15 kg/m^2 before and after the 8-week intervention program, respectively (n=100). Although there was no significant difference be-

tween the measurements with respect to the combined BMI values before and after the intervention program, the BMI values in general were high. The mean BMI values for the diet and diet-plus-exercise groups were significantly reduced after the 8-week intervention program compared with those measured before the program. The BMI value of control group was slightly, but not significantly increased. Hadden *et al* (1975) has shown the effectiveness of diet in control of plasma glucose levels by reducing the patients plasma glucose level to 70 mg/dl with 6 months of intensive dietary management causing a 10% reduction in body weight. In the British regional heart study, investigating the risk factors for non-insulin dependent diabetes among men, Perry *et al* (1995) reported a correlation between physical activity level and development of type 2 diabetes. High BMI was the dominant risk factor for diabetes. They also reported that men engaged in moderate levels of physical activity had a substantially reduced risk of diabetes compared to physically inactive men (Perry *et al*, 1995). In a study of obese adults, better results were obtained in the group that exercised and had a healthy diet in the reduction of body weight and the risk for metabolic diseases (Hagan, 1988).

In a long term protocol involving dietary treatment and/or increase of physical activity, Eriksson *et al* (1991) showed that exercise combined with diet provided better results with respect to weight loss and regulation of blood glucose in patients with type 2 DM. Our results revealed better glycemic control in the group that exercised and had a diabetic diet in an 8-week intervention program in patients with type 2 DM, which is consistent with the reports from the current literature.

A minor limitation of this study was that the initial HbA_{1C} percentages, between the groups, the main outcome measures of this study, were different. Significant reductions were achieved in the mean HbA_{1C} percentages for the diet and diet-plus-exercise groups, while the percentage increased slightly in the control group after the intervention program. Because the available information favors the effectiveness of diet combined with regular exercise on the regulation of blood glucose in type 2 DM patients, the patients with higher HbA_{1C} percentages were deliberately assigned, based on their desire, to this group. This was done to determine whether this regime would provide an advantage for those receiving diabetes education in a selected patient population over those left to their fate, receiving only oral antidiabetic therapy, not seeking or getting any service with respect to standard lifestyle recommendations for type 2 diabetes patients. A study involving older overweight African-Americans with type 2 DM reported that intervention involving regular physical activity were more effective in decreasing HbA_{1C} values and blood pressure than their usual care (Agurs-Collins, 1997). It was also reported that regular exercise reduces the development of microvascular complications in patients with type 1 diabetes (Franz, 1997).

It is known that weight loss can have a long-term impact on glycemic control. It has been shown that a 5% reduction in body weight in type 2 DM patients resulted in significant improvements in HbA_{1C} percentages, as weight loss was shown to be significantly correlated with improvement in glycemic control at one year (Wing *et al*, 1987). In the US Diabetes Prevention Program, during 1996-1999, 58% of 3,234 enrolled overweight subjects with glucose intolerance achieved their target weight reduction goals with intensive lifestyle changes. The adherence rate of subjects to the planned exercise program was 78% (Diabetes Prevention Research Group, 2002).

In agreement with the above mentioned studies, those in our program who performed exercise with the diabetic diet achieved better results than those with the diabetic diet alone. The mean differences between the percentages of HbA_{1C} before and after the 8-week intervention program were -0.80±0.48% and -2.06±0.87%, for the diet and diet-plus-exercise groups, respectively. Epidemiological analysis in the UKPDS, which recruited 5,102 patients newly diagnosed with type 2 diabetes, who were followed for an average of 10 years, indicates that for every percentage point decrease in HbA_{1C} there was a 35% reduction in the risk of complications (UKPDS, 1998).

Reductions in HbA_{1C} via standard lifestyle changes, in addition to oral antidiabetic therapy, will delay the onset and/or slow the progression of microvascular complications, and thereby, im-

proving the length and quality of life for people with type 2 diabetes mellitus, reducing the cost of therapy. It has been reported that the cost of medical care for DM patients increases with the HbA_{1C} value. Due to the need for combined antidiabetic drug therapy and the development of complications, for every 1% increase in HbA_{1C} the cost of medical care increases by 7% (Gilmer *et al*, 1997).

Our results are in agreement with the results of small and larger scale studies indicating the importance of lifestyle changes in the management of type 2 DM. For people with newly diagnosed type 2 diabetes, first line therapy involves diet modification and performing regular exercise. If the disease can not be controlled with these alone, oral medications and/or injected insulin may be added. Research has shown that regular physical activity improves glucose and lipid metabolism, reduces blood glucose, blood pressure, body weight, body fat, and insulin resistance and improves lipid profiles (ADA, 2002; Horton, 2000). Research has shown that routine exercise regimens reduce blood glucose, blood pressure, body weight and body fat, and improve lipid profiles.

In conclusion, the results from this 8-week intervention program with type 2 diabetes patients living in the service area of two health centers in Elazig, Turkey, indicates that lifestyle changes involving diet or diet-plus-exercise resulted in a significant decrease in HbA_{1C}, with the diet-plus-exercise regimen being more effective. Therefore, education and intervention programs should be developed in the primary health care centers that are involved in first stage health services, but are usually engaged in prescription renewal services. Since primary health care providers have a better chance to meet with patients, promotion of diabetes education and intervention programs by these centers will increase the effectiveness of diabetes therapy, and will delay the onset or the progression of microvascular complications, improve the length and quality of life for diabetes patients and reduce the associated medical costs.

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