# Response of Non-insulin-dependent Diabetic Patients to an Intensive Program of Diet and Exercise

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To assess the effectiveness of the Pritikin program of diet and exercise for treating patients with non-insulin-dependent diabetes mellitus (NIDDM), data were obtained from 60 patients who completed the 26-day residential program. Of the 23 patients who were taking oral hypoglycemic agents upon entry, all but 2 were off medication by the end of the program. Of the 17 patients who were taking insulin, all but 4 were off medication at discharge. Two of the four had their insulin reduced by 50% while the remaining two had no major change in their insulin dosage. Fasting blood glucose was reduced from 194.9 ± 10.1 to 144.6 ± 7.1 mg/dl. Serum cholesterol was reduced from 225.4 ± 5.7 to 181.7 ± 4.9 mg/dl while triglycerides were reduced from 283.7 ± 28.8 to 186.2 ± 11.6 mg/dl. The group as a whole lost an average of 4.3 kg/body wt and achieved 40.5% of their desired weight loss. Maximum work capacity increased from 5.6 ± 0.3 to 7.9 ± 0.4 METs, while daily walking increased from 11.7 ± 2.4 to 102.8 ± 4.8 min/day. The decrease in fasting glucose was not correlated with weight loss ($r = 0.24$), increase in walking time ($r = 0.00$), or increase in MET capacity ($r = 0.05$). We conclude that the total program is an effective means for treating NIDDM patients. We also feel that the high-complex-carbohydrate, high-fiber, low-fat diet is of primary importance. DIABETES CARE 5: 370–374, JULY–AUGUST 1982.



It is estimated that there are approximately eleven million diabetic patients in the United States. A vast majority of these have non-insulin-dependent diabetes mellitus (NIDDM). Many are maintained on oral hypoglycemic agents or insulin in an attempt to normalize their serum glucose. Recently, emphasis has been placed on decreasing or eliminating the use of these medications by using other methods of treatment to normalize blood glucose. Classically, weight reduction in combination with a reduction in carbohydrate intake has been recommended for overweight diabetic patients. Recently, the American Diabetes Association has revised their dietary recommendations to increase the consumption of complex carbohydrates and foods high in fiber.[1] Weight control and exercise, especially in the non-insulin-dependent, obese diabetic person, are also emphasized. The program of diet and exercise described by Pritikin and McGrady[2] consists of a high-carbohydrate, high-fiber, low-fat diet, in addition to weight control and exercise. The purpose of this article is to evaluate the short-term progress of 60 NIDDM patients who completed the Pritikin Longevity Center 26-day residential program.

## PATIENTS AND METHODS

Sixty patients with NIDDM spent 26 days at the Pritikin Longevity Center where they underwent an intensive dietary modification and exercise program. The mean age of the patients was 61.5 ± 1.2 yr ($\bar{x}$ ± SE), with a range of 35–82 yr. A history of diabetes ranged from 0.5 to 40.0 yr in these patients. The population was subdivided according to sex, men (N = 40), and women (N = 20), and according to whether medication was taken (N = 40) or not taken (fasting glucose > 120 mg/dl, N = 20). This group of 60 included all documented NIDDM patients who completed the Pritikin Longevity Center program between February 1979 and June 1980. Thirty-nine of the patients had either peripheral or coronary atherosclerosis in addition to diabetes mellitus.

The patients first registered at the Center. After dinner they were given an orientation and instructions for a 12-h fast. The following morning, blood samples were obtained with the patients in a seated position. All samples were analyzed for total cholesterol, triglycerides, uric acid, and glu-

cose on a Technicon Autoanalyzer (Bio-Science Laboratories, Van Nuys, California). The patients were then examined by a physician and given approval for a graded treadmill exercise test. At this time, most of the patients were told to start reducing their medication. Twenty-three patients were taking oral hypoglycemic agents and 17 were on insulin. The insulin dosages ranged from 14 to 75 U/day.

Before the treadmill test, girth measurements were obtained at the upper arm, chest, abdomen, thigh, and wrist. Skinfold fat measurements were obtained from the triceps, subscapula, abdomen, and midthigh, as described by Wilmore et al.[3] Lean body weight was calculated from the measurements and used to estimate a desirable body weight (24% fat for women and 15% for men). Forty-two of the 60 patients were more than 10% above their desirable body weight and were placed on a 900 kcal/day diet. All others ate ad libitum.

The patients were then given a standard 12-lead resting electrocardiogram and graded treadmill exercise test, as described previously.[4] The test was terminated at 90% of age-predicted maximum heart rate, 2.0 mm ST depression, plus 2 angina, on a scale of 1–4, or other established medical criteria.[5]

Immediately after the treadmill test, the patients were privately counseled and an individualized walking program was prescribed. The program usually consisted of two 30–45-min walks a day, at the training heart rate that was determined from the initial treadmill test (70–85% of maximum age-predicted heart rate or 85–95% of maximum symptom-free or nonischemic heart rate, as appropriate). At the end of the second week, the prescriptions were reevaluated and the patients were encouraged to increase their walking distance. In addition, each patient attended a supervised exercise class 5 days a week. The class consisted of 10–20 min of stretching and flexibility activities and 40–50 min of aerobic exercises (treadmill or exercycle).

The patients were seen twice weekly by their physicians to evaluate their progress and regulate their medication. Fasting blood samples were obtained at the beginning of each week for analyses. Additional samples for glucose determinations were obtained when ordered by the physician. At the end of the session, the treadmill test was repeated. The patients were also given a final exercise prescription to take home to continue their exercise program.

During the 26-day session, the patients were served and taught to prepare the high-complex-carbohydrate, high-fiber, low-fat diet described by Pritikin. Less than 10% of the calories were obtained from fat (unsaturated/saturated 1.85), 13% from protein, and the remainder from carbohydrate (90% complex). Ten to twenty grams per day of crude fiber was obtained from the diet. The diet contained less than 25 mg of cholesterol and 4 g of sodium chloride per day. Protein was derived from other than animal sources, with the exception of nonfat milk, which was served daily, and small amounts of fish or fowl, which were served weekly. Neither alcohol, tobacco, nor caffeinated beverages were permitted during the 26-day session.

Daily lectures were used to explain to the patients the need for a major change from the typical American lifestyle in order to prevent or control degenerative diseases. Several lectures focused directly on diabetes and weight control.

To assess the effectiveness of the overall program on NIDDM patients, data from 60 patients were analyzed using the paired Student's $t$ test with $P < 0.05$ accepted as significant. Correlation coefficients and analysis of covariance were performed on the UCLA computer to assess possible interaction between the various treatments imposed on the patients.

## RESULTS

*Exercise and body weight data.* Table 1 summarizes the exercise performance and body weight changes achieved by all 60 patients. Daily walking increased from 11.7 ± 2.4 to 102.8 ± 4.8 min/day (827.8%). The men increased their walking time by 95.2 ± 6.7 min while the women increased their time by 84.2 ± 8.1 min. Maximum aerobic work capacity increased from 5.6 ± 0.3 to 7.9 ± 0.4 METs (41%). Similar increases in MET capacity were achieved by both the men (2.3 ± 0.3 METs) and women (2.1 ± 0.5 METs) patients. These increases in exercise capacity were all significant at $P < 0.05$.

The group as a whole lost an average of 4.3 ± 0.4 kg and achieved 40.5% of their recommended weight loss. The men lost an average of 4.7 ± 0.5 kg and achieved 47 ± 5% of their recommended weight loss while the women lost 3.5 ± kg and achieved 34 ± 6% of their recommended weight loss. Of the total group of 60 patients, 7 lost less than 1.3 kg.

*Medication status.* Of the 23 patients who were taking oral hypoglycemic agents at entry, all but 2 could follow the advice to discontinue their medication without complications. Of the 17 patients who were on insulin, 13 had discontinued

TABLE 1
Effects of the Pritikin 26-day residential program on body weight, walking time, and MET changes in NIDDM patients

| | | Body weight (kg) | Walking (min/day) | METS |
|---|---|---|---|---|
| All subjects (N = 60) | Pre | 83.2 ± 2.5 | 11.2 ± 2.4 | 5.6 ± 0.3 |
| | Post | 78.9 ± 2.2 | 102.8 ± 4.8 | 7.9 ± 0.4 |
| Men (N = 40) | Pre | 88.8 ± 3.1 | 11.0 ± 2.8 | 6.0 ± 0.4 |
| | Post | 83.6 ± 2.9 | 106.3 ± 5.7 | 8.3 ± 0.5 |
| Women (N = 20) | Pre | 73.0 ± 3.2 | 11.5 ± 4.4 | 4.8 ± 0.4 |
| | Post | 68.6 ± 2.9 | 95.8 ± 8.6 | 6.9 ± 0.8 |
| Medicated (N = 40) | Pre | 81.9 ± 3.2 | 14.2 ± 3.1 | 5.5 ± 0.5 |
| | Post | 77.6 ± 2.8 | 97.6 ± 5.8 | 7.8 ± 0.5 |
| Nonmedicated hyperglycemics (N = 20) | Pre | 86.3 ± 3.6 | 4.2 ± 2.4 | 5.9 ± 0.6 |
| | Post | 82.0 ± 3.3 | 114.7 ± 7.9 | 8.1 ± 0.7 |

Values are mean ± standard error; all post values are significantly different, $P \leq 0.001$.

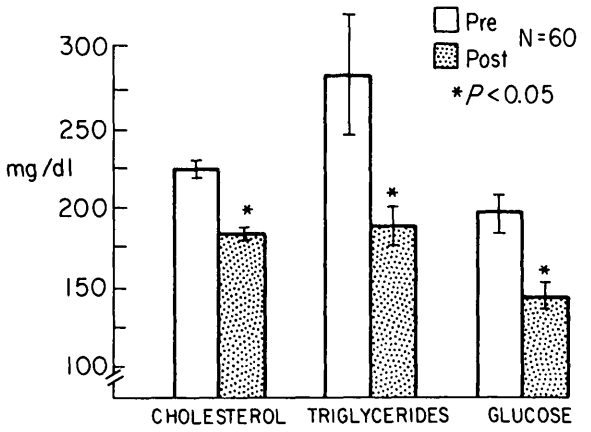


*FIG. 1. Effects of the Pritikin program of diet and exercise on serum lipids and fasting glucose in NIDDM patients.*

their medication by the end of the program. Of the remaining 4 patients, 2 had their insulin decreased by 50% while 2 had no major change in their insulin dosage.

*Laboratory results.* The group as a whole demonstrated a reduction in their fasting blood glucose from 194.8 ± 10.1 to 144.6 ± 7.1 mg/dl (20%) (Figure 1). The medicated group reduced their fasting glucose from 202.3 ± 12.2 to 151.4 ± 9.9 mg/dl (25%) while the nonmedicated, hyperglycemic patients reduced their glucose from 170.9 ± 11.8 to 123.8 ± 7.8 mg/dl (22%) (Table 2). When grouped according to sex, the men decreased their fasting glucose by 45.6 ± 10.1 mg/dl (24%) while the women reduced their glucose by 23.0 ± 14.9 mg/dl (11%) ($P \leq 0.1$). All other decreases were significant at $P \leq 0.05$. Figure 2 shows the changes in fasting glucose and the discontinuation of medication for the 23 patients initially taking oral hypoglycemic agents. Figure 3 shows the changes in fasting glucose and

TABLE 2
Effects of the Pritikin 26-day residential program on fasting glucose and serum lipids in NIDDM patients

| | | Cholesterol (mg/dl) | Triglycerides (mg/dl) | Glucose (mg/dl) |
|---|---|---|---|---|
| All subjects (N = 60) | Pre | 225.4 ± 5.7 | 283.7 ± 28.8 | 194.8 ± 10.1 |
| | Post | 181.7 ± 4.9* | 186.2 ± 11.6 | 144.6 ± 7.1* |
| Men (N = 40) | Pre | 215.8 ± 6.4 | 246.9 ± 24.0 | 189.2 ± 12.4 |
| | Post | 171.9 ± 4.4* | 162.2 ± 8.6* | 143.6 ± 9.3* |
| Women (N = 20) | Pre | 244.6 ± 10.3 | 357.5 ± 70.4 | 205.7 ± 14.8 |
| | Post | 201.3 ± 10.6* | 234.1 ± 27.6* | 182.8 ± 13.5 |
| Medicated (N = 40) | Pre | 233.1 ± 7.4 | 289.4 ± 38.2 | 202.3 ± 12.2 |
| | Post | 186.2 ± 6.6* | 192.0 ± 15.3* | 151.4 ± 9.9* |
| Nonmedicated hyperglycemic (N = 20) | Pre | 207.4 ± 6.6 | 270.6 ± 37.3 | 170.9 ± 11.8 |
| | Post | 171.1 ± 4.9* | 172.5 ± 14.7* | 132.8 ± 7.8* |

Values are mean ± standard error.
* Post values significantly different $P \leq 0.05$.

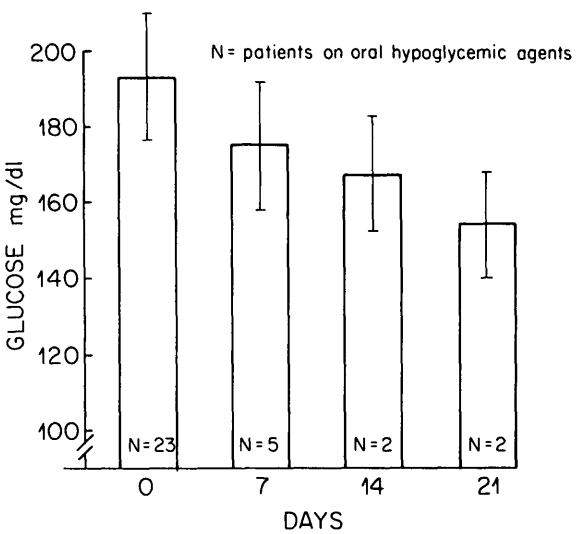


*FIG. 2. Response of fasting glucose and medication status to the Pritikin 26-day residential program in 23 NIDDM patients initially taking oral hypoglycemic agents.*

medication status for the patients who were taking insulin upon entry into the program.

For the group as a whole, the significant decrease in fasting blood glucose was not correlated with body weight change (r = 0.24), increase in walking time (r = 0.00), or increase in MET level (r = 0.05). Significant correlations ($P \leq 0.05$) were obtained between the decrease in fasting glucose and decrease in cholesterol (r = 0.39) and triglycerides (r = 0.34). The highest correlation was obtained be-

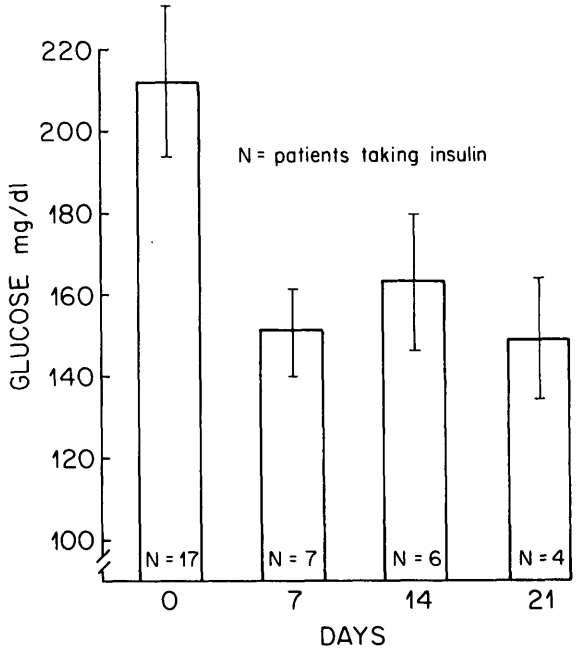


*FIG. 3. Response of fasting glucose and medication status to the Pritikin 26-day residential program in 17 NIDDM patients taking insulin.*

tween the baseline level of glucose and the decrease in glucose (r = 0.67).

Triglyceride levels decreased from 283.7 ± 28.8 to 186.2 ± 11.6 mg/dl for the entire group (Figure 1). The decrease in triglycerides was highly correlated with baseline values (r = 0.93) but not correlated with increases in walking time (r = 0.05) or MET capacity (r = 0.03). There also was no significant relationship between the decrease in triglycerides and body weight loss (r = 0.08).

Serum cholesterol showed a significant decrease from 225.4 ± 5.7 to 181.7 ± 4.9 mg/dl (Figure 1). The decrease in cholesterol was correlated ($P \leq 0.05$) with baseline values (r = 0.55) but was not related to a reduction in body weight (r = 0.15) or an increase in walking time (r = 0.23) or MET capacity. The decrease in cholesterol was correlated with the decrease in triglycerides (r = 0.43).

*Follow-up.* Upon leaving the Longevity Center all patients are invited to participate in a follow-up program to chart their progress. Fasting blood samples are sent to the Center for routine analyses and questionnaires are completed indicating medication status, adherence to the diet and exercise program, as well as other related information. Follow-up information was obtained from 11 (48%) of the patients who were initially taking oral hypoglycemic agents. Follow-up time ranged from 3 to 13 mo with a mean of 7.8. Of the two patients who were still on Diabinese (Pfizer Laboratories) at discharge, one had discontinued medication by 12 mo of follow-up and had a fasting glucose of 117 mg/dl. The second patient on Diabinese at discharge had no change in medication status. The mean fasting glucose at follow-up was 137.0 ± 16.7 mg/dl compared with 150.9 ± 18.9 at discharge. Three patients did, however, resume their oral medication.

Follow-up information was also obtained from eight (42%) of the patients who were initially taking insulin upon entry into the program. One of these patients was on insulin at discharge and had no change in medication at follow-up. Of the remaining seven patients, all had discontinued their use of insulin at the Center and were still off insulin at follow-up (1–12-mo range; $\bar{x}$ 6.4 mo). Their fasting glucose at follow-up was 187.6 ± 19.4 mg/dl compared with 143.6 ± 20.5 mg/dl at discharge.

## DISCUSSION

The results of this study clearly show that the Pritikin 26-day residential program of exercise, weight control, and high-carbohydrate, high-fiber, low-fat diet is more effective than treatment currently taken by most patients with NIDDM. At the end of 26 days the patients had a mean decrease in fasting blood glucose of 50.2 mg/dl. The decrease in fasting glucose was accomplished along with the elimination of oral hypoglycemic agents in 21 of 23 patients and the elimination of insulin in 13 of 17 patients. The particular facet of the program responsible for the apparent alteration in peripheral insulin action in our patients cannot be determined from this study. However, the intercorrelation data indicate that weight loss and exercise were not major factors.

Previous studies have shown that a single bout of exercise can increase insulin receptor sensitivity.[6] In addition, some evidence suggests that regular exercise training increases the total number of insulin receptors and improves glucose tolerance.[6–9] Exercise, however, does not by itself eliminate glucose intolerance even when significant weight loss is achieved.[7,10] In our patients there was no significant correlation between the reduction in fasting glucose and either walking time or increase in aerobic work capacity.

Abnormal endocrine function including hyperinsulinemia and decreased insulin sensitivity has been well documented in obese individuals.[9,11–16] While hyperinsulinemia has been implicated in the pathogenesis of obesity and is known to produce abnormalities in lipid metabolism, some studies indicate that obesity may be the cause of hyperinsulinemia and not vice versa. Glucose intolerance and hyperinsulinemia can be induced in normal weight individuals by overfeeding and weight gain.[13,14] Conversely, caloric restriction and weight loss have been shown to be effective in amelioration of glucose intolerance.[12,15,16] Since weight loss achieved through increased caloric expenditure has only minimal effects on glucose intolerance, it seems obvious that the effects reported with caloric restriction would be due primarily to dietary modification and not weight loss per se. In our total group of patients the correlation between weight loss and decrease in fasting glucose was not significant. In addition, 7 of the 60 patients lost less than 1.3 kg during the 26-day period and still showed significant improvements in fasting glucose.

The effectiveness of the high-complex-carbohydrate, high-fiber, low-fat diet in controlling diabetes has been reported by other investigators.[17–24] Anderson et al.[17] placed 20 NIDDM patients on an isocaloric, high-carbohydrate, high-fiber diet and were able to reduce insulin medication from 32 ± 0 to 3 ± 1 U/day in 18 days. Fasting glucose was reduced from 165 ± 3 to 151 ± 5 mg/dl. Our results are very similar to those reported by Anderson et al.[17,20] and others[19–24] using a high-carbohydrate, high-fiber diet except that our patients showed a greater reduction in fasting glucose. The greater reduction in fasting glucose in our patients may have been due to the added effects of daily exercise. However, it still appears that the high-complex-carbohydrate, high-fiber, low-fat diet was the major factor responsible for the results achieved by our patients as well as those reported by others. The potential beneficial effect of being in a residential program with specially prepared food cannot be overlooked.

The reduction in serum lipids observed in this group of patients is similar to reductions reported earlier for patients with coronary heart disease who attended the Pritikin Longevity Center.[4] While exercise[25] and diet[24] have both been shown to be effective in reducing triglycerides, the reduction observed in cholesterol is more likely due to diet than exercise, as discussed previously.[4]

The limited follow-up data obtained from these patients is encouraging, particularly for those patients who were ini-

tially taking insulin. The data indicate that compliance to the program is good and in most cases is effective in supressing hyperglycemia. Of the three patients who had to resume the use of Diabinese, two indicated good compliance to the diet and had serum cholesterol values of 149 and 160 mg/dl at follow-up. The third individual indicated poor compliance and had a serum cholesterol of 220 mg/dl at follow-up.

In conclusion, the high-complex-carbohydrate, high-fiber, low-fat diet combined with daily walking appeared to be a more effective regimen for treating these NIDDM patients than their previous management program. Since patients with NIDDM are at high risk for the development of cardiovascular disease,[26] this type of diet and exercise regimen may significantly lower this risk by not only influencing the level of hyperglycemia but by significantly reducing serum lipids. Our limited short-term follow-up data are encouraging. Further studies are presently underway to assess the long-term compliance to this program. Anderson[27] has reported long-term success (up to 51 mo) with a similar high-carbohydrate, high-fiber diet in a small number of patients.

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