# DIETARY COMPLIANCE AMONG PERSONS COMPLETING DIABETES EDUCATION CLASSES


By

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## PREFACE

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## CHAPTER I

## INTRODUCTION

Diabetes mellitus is a major, yet often underestimated, health problem in this country. Incidence of the disease has steadily risen from five people for every 10,000 in 1936 to 26.7 people per 10,000 today. The following statistics clarify the extent of the problem in the United States ("Diabetes facts", 1985; "1985 fact sheet", 1985):

1. There are seven million diagnosed diabetics; an estimated five million more are undiagnosed.
2. More than 160,000 Oklahomans have diabetes ("Skaters to fight", 1986).
3. Each year 600,000 individuals develop diabetes.
4. The economic toll of diabetes, according to the latest government statistics, is 18 billion dollars each year.
5. Annually, over two million people are hospitalized because of diabetes.
6. Black Americans have a rate of diabetes 30 to 40 percent higher than the norm.
7. Hispanics are three time more prone to develop the disease than are other ethnic groups.
8. Diabetes with its complications is the third leading cause of death in this country.

9. Indirectly, more than 50 million people are affected by diabetes, because of its hereditary nature and its impact on the entire family.

In spite of the above statistics, however, the full implications of this disease are frequently underestimated. It is often assumed that insulin and oral hypoglycemic agents control and, for all practical purposes, cure diabetes. This assumption, unfortunately, is not true because of the complications of the disease. These complications include retinopathy, neuropathy, nephropathy, infant mortality, birth defects and coronary heart disease. Diabetics are 25 times more prone to blindness in 20 to 74 year olds. Diabetics are five times more prone to gangrene and are 17 times more likely to develop kidney disease than the general population. Furthermore, the risk of heart disease and strokes is doubled in people with diabetes ("Diabetes facts", 1985).

Dr. John Muchmore, a physician and chairman of the Oklahoma City chapter of the American Diabetes Association, has noted that complications will eventually occur to some extent, even in diabetic patients with excellent control of their blood sugar (Clay, 1985). The rate at which the complications occur, however is strongly affected by the amount of blood glucose control achieved by the diabetic (Palmer, 1985). Control is achieved through diet, medication and/or exercise.

A number of recent studies have been designed to evaluate the effects of diet, particularly of a high carbohydrate, high fiber, low fat diet on blood sugar and blood lipid levels in diabetics. The results of this research have been exciting. Blood sugar levels have been normalized to the point where insulin or other medication can be reduced or even discontinued. Certain fibers also appear to lower the levels of lipids in the blood, especially of blood cholesterol. The implications of these studies indicate enormous potential for improving the health and quality of life for thousands of people with diabetes. The studies have varied greatly, however, in the types and amounts of fiber used, the method in which fiber was incorporated into the diet and the results obtained. Therefore, more research is required before the effects of high carbohydrate, high fiber, low fat diets will be understood, and diets can be designed to meet the needs of individual diabetic patients.

Another area requiring further research is the compliance of persons with diabetes to their menu plans and the nutritional adequacy of their dietary intakes. The exciting possibilities mentioned above will only be of practical benefit to diabetics if they are presented in such a way that patients are willing to accept and implement them in their daily lives. Therefore, this particular study was designed to assess current intakes of diabetics who completed a hospital diabetes education class and to compare those intakes to current dietary recommendations of the American Diabetes Association and the American Dietetic Association.

It is the hypothesis of the researcher that diabetic subjects who have completed a hospital diabetes education class will consume diets that tend to meet or exceed two-thirds of the Recommended Dietary Allowances for major nutrients. The objectives of this study are:

1. to determine the subjects' basic nutrition understanding about saturated and unsaturated fats, simple and complex carbohydrates and dietary fiber;
2. to evaluate the adequacy of dietary intakes of major nutrients and dietary fiber by comparing them to the Recommended Dietary Allowances and to current recommendations; and
3. to compare average fasting blood glucose levels to intake of carbohydrate, fat and dietary fiber.

# CHAPTER II

## REVIEW OF LITERATURE

Dietary recommendations for diabetic patients have changed significantly throughout history, and research within the last few decades has brought a radical reversal in the earlier recommendations. This reversal is primarily the result of experimental findings on the roles of carbohydrate, fat and dietary fiber in blood sugar control and more recently, the glycemic response of foods. The following literature review presents a historical overview of diabetic diets and the recent discoveries upon which current dietary recommendations are based. The effects of carbohydrate, fat and fiber on glycemic response are discussed, as well as practical aspects of implementing a high carbohydrate, high fiber, low fat diet. These include palatability and patient compliance.

### Diabetic Diets, Past and Present

#### Diabetic Diets Throughout History

Diabetes was first described as a disease in the Ebers Parchment, written about 1000 years before Hippocrates. Diet was considered to be the primary form of therapy even at that time, and a high carbohydrate diet was the only treatment known to be effective.

From that time until the present, dietary recommendations have fluctuated greatly, using varying amounts of carbohydrate and fat (Crapo, 1981). A historical view of some of these recommendations is presented in Table I.

Generally speaking, the most widely accepted method of diet therapy throughout history has been to restrict carbohydrate intake. This practice did not begin to change until the latter part of the twentieth century, when the recommendations for restricted carbohydrate, high fat diets began to be reversed. This reversal in part developed from the realization that coronary heart disease is a major threat to people with diabetes. Problems such as hyperlipidemia and atherosclerosis, which are commonly found in diabetics, can be partially prevented or controlled with low fat diets (Bierman, 1985).

The other major factor in the recent evolution of dietary recommendations for diabetics has been the recognition of the effect of a liberal dietary intake of complex carbohydrates, particularly those high in fiber. In 1972, Trowell hypothesized that for those who are susceptible, dietary fiber is protective against diabetes, obesity, hyperlipidemia and ischemic heart disease (Kelsay, 1978). This hypothesis was based on his observations in Africa regarding the rare incidence of diabetes among the rural population there, as well as upon epidemiological data in England (Trowell, 1978). A study of African hospital patients south of the Sahara indicated that from 1920 to 1960 diabetes had been a rare disease. This apparently was related to the high carbohydrate, low fat diets typical of that region. Incidence of ischemic heart disease in this area is still rare, even

TABLE I

A HISTORICAL VIEW OF DIABETIC DIETS[1]

| Date | Source | Carbohydrate | Fat |
|---|---|---|---|
| 1550 B.C. | Ebers Papyrus (Egypt) | High | |
| 0001 A.D. | Aretaeus (Asia Minor) | High | |
| 1675 | Willis | High | |
| 1797 | Rollo | Very Low | High |
| 1860–1880 | Bouchardat | Low | High |
| 1900–1920 | Naunyn; Allen | Low (+fasting) | Low |
| 1900–1920 | von Noorden | High | |
| 1923 | Geyelin | High | |
| 1929 | Sansum | Normal | Normal |
| 1931 | Rabinowitch | Moderate | Low |
| 1935 | Himsworth | High | |
| 1940–1960 | Kempner; Ernest | High | Low |
| 1940–1970 | A.D.A. (U.S.) | Limited | Moderate |
| 1971 to date | A.D.A. (U.S.) | Increased | Reduced |

[1]Crapo, 1981.

among diabetics (Trowell, 1975). In the middle 1930's, autopsies were performed on 1000 blacks from Nairobi; only three cases of diabetes were found. Forty years later there were many obese people in urban areas of East Africa, and a diabetes clinic had been established in every city (Trowell, 1978). The transition from the typical rural diet to the more western-style diet of urban dwellers appeared to have caused this change.

The second source of information upon which Trowell based his hypothesis was the epidemiological data from England during World War II. Female death rates were adjusted for age differences and compared from 1933 to 1957. In 1941, the diabetes death rate for females began to fall and continued falling almost every year until 1954; the total decrease was 54 percent. This decrease does not appear to have been the result of lower sugar and fat intakes. Rather, cereal consumption in 1941 rose 22 percent, and the crude fiber concentration rose 50 percent. During a time of war, the wheat flour milling extraction rate is raised from 70 percent to 80 or 90 percent, in order to provide more cereal foods to man. When the milling rate rises only slightly, the resulting increase in fiber content is considerable (Trowell, 1978). Therefore, the most likely reason for the decrease in diabetic deaths during World War II was the simultaneous increase in cereal and fiber consumption.

These findings may be compared to estimates of current fiber intakes in the United States. Nonvegetarians in one study consumed eight to twelve grams of crude fiber daily. Crude fiber represents one-fifth to one-half of the total fiber in foods. During the nineteenth century the intake of fiber from fruits and vegetables fell about 20 percent; fiber intake from cereals and grains dropped about 50 percent (Kelsay, 1978). From 1880 to 1974, when the incidence of diabetes, heart disease and colon cancer was increasing there was an estimated decline by 90 percent in the consumption of cereal fibers (Anderson, Midgley and Wedman, 1979). Thus, according to current estimates, the average Western diet contains approximately 15 to 20 grams of dietary fiber a day (Bingham, 1987; Wavpotich, 1984). An intake of 25-35 grams is recommended (Trowell and Burkitt, 1986).

## Current Dietary Recommendations

Before this century there was no standardized method of controlling diabetes; methods by different doctors varied greatly. Then in 1950 the American Diabetes Association and the American Dietetic Association published Exchange Lists, which for the first time provided a standardized method for formulating diabetic diets (American Diabetes Association and American Dietetic Association, 1977). This was an invaluable tool. However, after 25 years a major revision was required in order to incorporate more recent information on food composition and to emphasize a diet lower in total fat and high in polyunsaturated fat. The new book, Exchange Lists for Meal Planning, was published in 1976 by the American Diabetes Association, the American Dietetic Association and the National Institutes of Health. This book was recently updated to provide diabetics greater flexibility in meal planning. A variety of new foods have been added to the exchange lists, including combination foods such as casseroles. Greater emphasis was placed on the importance of complex carbohydrates, and symbols were included to help the patient easily determine which foods are high in dietary fiber and which are high in sodium. The updated version of Exchange Lists for Meal Planning was published in 1986 (American Diabetes Association and American Dietetic Association, 1986; Franz, Holler, Powers, Wheeler and Wylie-Rosett, 1987).

The change evidenced by the 1986 revision in the Exchange Lists for Meal Planning from a carbohydrate restricted, high fat diet to one high in complex carbohydrates and low in fat was initially presented by the Committee on Food and Nutrition of the American Diabetes Association in a pioneering statement published in 1971 (Bierman, 1985). The Committee recommended that rather than restricting carbohydrates in the diabetic diet, foods high in complex carbohydrates should be emphasized. Such foods include whole grains and many vegetables and fruits. The Committee also recommended that foods high in fat and cholesterol should be limited. These dietary guidelines were based on studies which indicated the benefits of diets high in complex carbohydrates, as well as research on the high incidence of coronary heart disease among diabetics, and the apparent role of a high fat diet in its development.

During the seventies evidence continued to accumulate which supported the dietary recommendations of the Committee. Therefore, in 1979 the Committee published a statement reaffirming and updating their recommendations. The report included the following statements

(American Diabetes Association, 1979):

> 1. Although it is not certain that restriction of dietary saturated fat and cholesterol and replacement with unsaturated fat will slow the progression of atherosclerosis, it is a reasonable expectation. Therefore, dietary sources of fat that are high in saturated fatty acids and foods containing cholesterol should be restricted.
>
> 2. [Dietary Fiber] has been reported to lower postmeal plasma glucose in diabetic persons. Although the long-term effects of dietary fiber in diabetic persons are unknown, it seems reasonable that the amount of food fiber to estimated in any given diet. Wherever acceptable to the patient, natural foods containing unrefined carbohydrate with fiber should be substituted for highly refined carbohydrates, which are low in fiber. Changes in fiber content of the diet should be brought to the attention of the physician, since they may change insulin requirements.

The following recommendations were also made for diet composition: protein should provide 12 to 20 percent of the total energy intake, carbohydrates 50 to 60 percent, and fat the remaining 20 to 38 percent. The fat intake should further be divided so that saturated fatty acids provide less than 10 percent of the total calories, polyunsaturated fatty acids comprise about 10 percent and the remainder is obtained from monounsaturated sources.

Gradually these recommendations of the American Diabetes Association have received acceptance, and other organizations have issued similar statements. Doctors and dietitians are beginning to incorporate the guidelines into the treatment of their patients and the results have been promising.

Patient Compliance

The importance of recommending a diet which will prevent wide swings in blood sugar and therefore aid in controlling diabetes is obvious. However, recommendations for the best possible diet are without value unless the patient is willing to follow that diet. Thus, the problem of patient compliance is a crucial factor in the treatment of diabetes.

Studies evaluating compliance to diabetic diets appear to be limited. One study involving 178 insulin-dependent diabetics was designed to assess the level of dietary compliance and to examine the relationship of compliance to diabetic control (McCulloch et al., 1981). When questioned about their prescribed carbohydrate exchange diet, it was found that only 19 percent of the subjects measured carbohydrate while 46 percent relied on guesswork. The remaining 35 percent admitted that their carbohydrate intake was completely unregulated. The level of compliance was quite discouraging. It should be noted, however, that the subjects had not been given any specific dietary advice or education.

Two other studies evaluated compliance following participant education and advice on low fat diets. One study involved 40 insulin-dependent diabetics who were followed for 10 months; both knowledge and compliance remained high throughout the duration of the study (McCulloch, Mitchell, Tattersall and Amber, 1984). The other study evaluated the compliance of 170 noninsulin-dependent diabetic women for six months (de Bont et al, 1981). In this study fat intake in the test group fell from 41 percent to 31 percent of the total calories, and carbohydrate intake increased from 38 percent to 46 percent. Mean plasma total cholesterol in the test group also fell significantly; there was no change in mean plasma glucose. Thus, in both studies compliance and results were good following dietary counseling.

Another study tested long-term patient compliance to a diet high in carbohydrate and dietary fiber (Geekie, Eaton, Simpson and Mann, 1981). Fifteen diabetics followed the diet for a period of two years. Although they consumed an average of only 41 percent carbohydrate and 27 grams of dietary fiber, this was significantly higher than the previous intake of 32 percent total calories from carbohydrate. These English diabetics found it difficult to locate high fiber foods. However, dietary modifications maintained for such a long time period are encouraging. Compliance among diabetic persons in general appears to be limited. Nevertheless, education and dietary counseling may greatly increase compliance, particularly when compliance results in better diabetic control to further encourage the patient.

## The Effect of Carbohydrate, Fiber and Fat on Glycemic Response

### Recent Experimental Findings

A number of different studies have been designed, especially in the last 10 years, to determine the effects of low fat, high carbohydrate, high fiber diets on diabetics. Various types of fiber have been added to the diet by a number of different methods, some in conjunction with other dietary changes. The results obtained have also varied greatly.

One important study was designed to determine the effects of a high carbohydrate, high fiber intake on blood sugar control (Kiehm, Anderson and Ward, 1976). The 13 men all had significant fasting hyperglycemia before treatment; all required insulin or sulfonylureas, and five were obese. Initially, the men were given American Diabetic Association diets for a week until fasting plasma glucose values were stabilized. These diets provided 43 percent of the calories as carbohydrate, 23 percent protein, 34 percent fat and an average of 4.7 grams of crude fiber daily. They were then changed to a high carbohydrate diet (75 percent carbohydrate) which provided an equivalent number of calories and averaged 41.2 grams of crude fiber a day. The men were on this diet approximately two weeks.

In eight of the patients, insulin and sulfonylurea treatment was gradually reduced and discontinued; in the other five, insulin was reduced. Moreover, the fasting plasma glucose values of 10 of the men were significantly lower at the completion of the two weeks. Of seven patients who averaged 16.4 grams of fiber daily, the fasting triglyceride levels decreased to a level 31 percent lower than on the American Diabetes Association diet. Also, cholesterol levels in all 13 patients decreased significantly.

Another research project with significant results was a long-term study by Dodson, Stocks, Holdsworth and Galton (1981). This study involved 44 patients, both insulin-dependent and noninsulin-dependent diabetics. The patients consumed a high fiber, high carbohydrate, low fat diet for a duration of three months. Interestingly, the composition of the diet was based on the Ugandan diet typical around 1930 because, as mentioned earlier, Trowell found the incidence of diabetes mellitus to be quite low in that particular population. The insulin-dependent diabetics received 20 grams of guar gum, while the noninsulin-dependent diabetic patients received an equal amount of wheat bran. The diet was well tolerated.

The results obtained were quite significant. In the insulin-dependent diabetic patients, the amount of insulin required decreased, but weight loss and changes in blood glucose were not significant; there was a significant decrease in low density lipoprotein cholesterol and in the total cholesterol to high density lipoprotein cholesterol ratio; total serum triglyceride levels did not change significantly. In the noninsulin-dependent diabetics, mean weight loss was 7.4 kilograms, and drug therapy (biguanide and sulfonylurea) was decreased. There was a significant increase in high density lipoprotein and a decrease in the ratio of total cholesterol to high density lipoprotein; the drop in serum triglycerides was insignificant. The two patients at ideal body weight when the regimen began did not lose weight, but were able to quit drug therapy entirely. In the nondiabetic controls who were also on the diet, there was significant weight loss, an increase in high density lipoprotein, decreased total cholesterol to high density lipoprotein ratio, and a decrease in the low density lipoprotein to high density lipoprotein ratio. However, fasting blood glucose levels and total serum triglyceride levels did not change significantly.

Thus, the diet apparently resulted in important changes both in glucose metabolism and in lipid metabolism. The changes in lipids were probably affected by the low fat intake as well as by the high levels of carbohydrate and fiber in the diet. Also, decreased caloric intake may well have affected weight loss and led to the lessened requirement for drug therapy.

Results similar to those in the two studies above were obtained when 20 lean diabetic men requiring insulin were placed on a high carbohydrate, high fiber diet for 16 days (Anderson and Ward, 1979). This diet, which was preceded by a control diet containing 43 percent of the calories as carbohydrate, provided 70 percent calories as carbohydrate, 21 percent as protein and 9 percent as fat. The test diet resulted in lower fasting and three-hour postprandial plasma glucose levels in most patients. This improvement occurred dispite a reduction in the average insulin dose of 15 units a day. Insulin therapy was discontinued completely in all of the men. Serum cholesterol values decreased from 206 to 147 milligrams per deciliter on the experimental diet; however, no significant change occurred in fasting serum triglyceride values. In this case, the diet high in carbohydrate and fiber and low in fat caused a rather dramatic drop both in plasma glucose levels and in serum cholesterol.

Another study with a different design involved six insulin-dependent diabetics who received continuous insulin infusion with a pump (Chenon, Phaka, Monnier, Colette, Orsetti and Mirouze, 1984). The short-term study compared three breakfast/lunch combinations: a) conventional breadfast and lunch; b) fiber supplemented breakfast, conventional lunch; and c) fiber supplemented breakfast and lunch. The carbohydrate content of all of the meals was 40 percent of the total calories. The fiber content of the conventional meals was five percent of the total carbohydrate content of all of the meals was 40 percent of the total calories. The fiber content of the conventional meals was five percent of the total available carbohydrate intake, while that of the fiber supplemented meals was 15 percent. The fiber in the meals occurred naturally within the foods, primarily in cereal grains and fruit.

After the conventional breakfast on the first day, there was a small rise in postprandial blood glucose. However, on the two days when fiber supplemented breakfasts were consumed there was no apparent rise in postprandial blood glucose. A slight improvement in the glycemic response was observed after the fiber supplemented lunch on day three. However, the decrease in postprandial blood sugar after breakfast was much more marked than the decrease that occurred after lunch. Furthermore, although recent studies in nondiabetic subjects have indicated that high fiber content in a meal can improve the glycemic response to the subsequent meal, that phenomenon was not observed in this particular situation, perhaps because carbohydrate content was not increased. In general, the authors recommend that high fiber intakes are beneficial for diabetics using continuous glucose infusion as well as for those using insulin or oral hypoglycemic agents.

Thus, it is evident that diets high in carbohydrate and fiber and low in fat may have beneficial effects in terms of blood glucose and blood lipids when incorporated into the diabetic diet. Questions still remain, however, as to the role of each component - carbohydrate, fiber and fat in the diet and the mechanisms by which glucose and lipids affect metabolism in vivo.

## Carbohydrate, Fat and Fiber: Their Roles and Mechanisms for Action

The high carbohydrate content of the diabetic diet apparently contributes more to the decrease in plasma glucose levels than does the fiber content. This fact is clearly demonstrated by an experiment designed to compare the effects of a high carbohydrate, high fiber diet to one high in carbohydrate but low in fiber (Anderson, Chen and Sieling, 1980). Eleven diabetic men received the two weight-maintaining diets in an alternating sequence. One contained 34 grams of plant fiber for each 1000 calories; the other provided 12 grams per 1000 calories. Both diets contained 70 percent carbohydrate, 18 percent protein and 12 percent fat. The control diet was comprised of 43 percent carbohydrate, 18 percent protein and 39 percent fat. Insulin doses on the control diet averaged 20 units a day. Required doses of insulin fell with the high fiber diet and the low fiber diet to 11 and 12 units, respectively. Fasting serum triglyceride values on the control and high fiber diets were similar, but fasting triglyceride values on the low fiber diet were 28 percent higher.

The results indicate that the high carbohydrate aspect of the diet is the primary factor which caused the decrease in blood sugar and insulin requirements (Anderson and Ward, 1978). There was no significant difference in the average insulin doses given when the fiber level in the diet changed. However, triglyceride values increased 28 percent when the high carbohydrate, low fiber diet was used. Interestingly, triglyceride levels were equivalent with the control diet and the high carbohydrate, high fiber, low fat diet. A diet high in carbohydrate tends to produce hypertriglyceridemia, but that effect is counterbalanced by the high amount of fiber (Anderson,1980; Anderson, Chen et al., 1980; Anderson, Midgley et al, 1979).

It therefore appears that the carbohydrate level in the diet is the most important factor in controlling blood glucose. A high carbohydrate diet improves the ability of the body to burn glucose, as well as increasing the number of insulin receptors. However, the fat content of the diet also affects glycemic response. A high fat diet blocks the uptake of glucose and decreases the number of insulin receptors, thus decreasing insulin sensitivity, in addition to raising blood lipid levels (Anderson, 1980; Anderson and Ward, 1979; Wavpotich, 1984). In short, there is an inverse relationship between insulin sensitivity and the amount of fat in the diet (Collier, McLean and O'Dea, 1984).

The effect of fat on glycemic response was further analyzed in a study comparing co-ingestion of fat and the response to slowly absorbed and rapidly absorbed carbohydrates (Collier et al., 1984). Seventy-five grams of carbohydrate were given in the form of lentils, which are absorbed slowly, or potatoes, which are rapidly absorbed. Both meals included 37.4 grams of fat. In both cases the fat significantly flattened the postprandial glucose curve; this was particularly true with the potatoes. This effect was probably caused by delayed gastric emptying. However, the postprandial insulin responses were not significantly reduced by fat in either case. The authors concluded that even when fat is present, the carbohydrate absorption rate has a major effect on postprandial glycemic response. Furthermore, insulin response to carbohydrate is not decreased in the presence of fat. These results are consistent with other experimental findings demonstrating the insulin resistance associated with high fat diets.

Finally, certain types of fiber have a significant hypoglycemic effect, particularly when used in conjunction with a high carbohydrate, low fat diet. It appears that a high intake of dietary fiber may increase tissue sensitivity to insulin (Anderson, Midgley et al., 1979). Diets rich in insoluble plant fibers such as wheat bran are associated more strongly with long-term effects on glucose tolerance than are diets high in soluble plant fibers such as pectins (Anderson and Chen, 1979). Other factors affecting fiber and glycemic response will be discussed later.

There are several possible mechanisms by which fiber may alter carbohydrate absorption and/or metabolism (Anderson and Chen, 1979):

1. Carbohydrate absorption may be slowed by delayed gastric emptying caused by soluble fibers; gastric emptying is accelerated by insoluble fibers.
2. Carbohydrate absorption may be slowed by the gels formed

by most soluble fibers.

3. Intestinal transit time, which is decreased by insoluble fibers and increased by soluble fibers, may influence the rate of carbohydrate absorption.

4. Available carbohydrate that is enclosed in plant fiber may be only partially digested.

5. Some of the starch in foods rich in fiber may not be digested or absorbed in the small intestine.

6. Other factors may exist, such as alterations in gastrointestinal hormones or pancreatic glucagon secretion.

Although dietary fiber works synergistically with carbohydrate to have a significant influence on glucose tolerance, it exerts an even more important influence on blood lipids. Soluble fibers have demonstrated distinct hypocholesterolemic effects in a number of studies (Anderson, 1980; Anderson and Chen, 1979; Anderson, Midgley et al., 1979; Anderson and Ward, 1979; Wavpotich, 1984). When incorporated into the diet these have been shown to lower low density lipoprotein cholesterol while raising high density lipoprotein cholesterol levels (Anderson and Chen, 1979; Wavpotich, 1984). Two foods which are particularly effective in this way are oat bran and legumes (Anderson et al., 1984). More specifically, pectins, guar and extracts of certain legumes are very effective in lowering serum cholesterol levels. Wheat bran and cellulose have little influence on serum cholesterol. Pectins appear to cause excessive fecal losses of bile salts; however, the mechanisms by which cholesterol is lowered are not fully understood (Anderson, Midgley et al., 1979). The three principle mechanisms which may be involved are: altered intestinal absorption, metabolism and release of cholesterol; altered hepatic metabolism and release of cholesterol; or altered peripheral metabolism of lipoproteins (Anderson and Chen, 1979). Other aspects of a high carbohydrate, high fiber, low fat diet also help reduce serum cholesterol, including restricted cholesterol, decreased saturated fat and increased polyunsaturated fat intake (Anderson, 1980).

Whereas water-soluble fibers are more effective in lowering serum cholesterol levels, insoluble fibers appear to be more effective in lowering serum triglyceride levels (Anderson, 1980). These effects are most evident in patients with hypertriglyceridemia. The three mechanisms listed for cholesterol metabolism may also explain the effect of fiber on triglycerides. It appears that fat absorption is slower and may occur lower in the intestinal tract in the presence of fiber (Anderson and Chen, 1979). However, this area has not been studied to any great extent, and many questions still remain unanswered.

## Practical Aspects of Implementing a High Carbohydrate, High Fiber, Low Fat Diet

### Factors Affecting Glycemic Response

The various effects of different types of fiber have been briefly discussed. One interesting study demonstrating these effects compared the results of a 50 gram glucose drink in relation to glucose response, insulin and gastric emptying. Thirty-eight healthy volunteers were given drinks containing either 2.5 grams or 7.0 grams ispaghula (the fiber found in Fybogel and Metamucil) or 2.5 grams or 14.5 grams guar gum. In addition, 14 noninsulin-dependent diabetics were given 7.0 grams of Fybogel. Previous findings had indicated that ispaghula husk lowered the blood glucose levels of diabetics when given with meals. In this particular study, however, the ispaghula given in a glucose drink appeared to have no effect. On the other hand, the drink containing 2.5 grams of guar gum was almost as effective as that with 14.5 grams in lowering blood glucose; both were quite effective (Manhire, Henry, Hartog and Heaton, 1981). This may be a very important finding. Administration of guar gum usually involves larger doses, which are frequently found to be unpalatable. If a much smaller amount, such as 2.5 grams, were found to be effective, therapeutic utilization of guar gum would be much more practical, and patient compliance would likely increase. It should be noted that the glucose drinks containing guar gum were not given to diabetic patients in this study. Therefore, further investigation would be required to demonstrate the effect of guar gum on the blood sugar of diabetic persons.

The viscous fibers generally have resulted in flatter postprandial blood glucose curves in both diabetic and nondiabetic subjects and in less urinary glucose loss in diabetics than have the nonviscous fibers. Viscous fibers include guar, tragacanth, konjac mannan, pectin and others (Jenkins et al., 1983). These fibers form viscous solutions in conjunction with water and result in increased transport time because they are largely insoluble (Parsons, 1984). The prolonged transport time results in slower absorption of glucose; thus, the glycemic response curve is flattened, independent of increased insulin secretion (Jenkins et al., 1980). It has been demonstrated that foods free of fiber, such as apple juice, cause higher postprandial insulin levels than do whole foods, such as apples, in amounts of equal caloric value (Goodhart and Shils, 1980; Worthington-Roberts, 1981). Other fibers, methyl cellulose and wheat bran for example, have also been shown to improve glucose tolerance, but to a lesser extent (Mahalko et al., 1984).

In addition to the type of fiber, other factors influence the results of fiber supplementation on glycemic response. One of these factors is the method by which the fiber is added to the diet. One research project which helps demonstrate this fact is a long-term study by Ray and associates (1983). Twelve obese noninsulin-dependent diabetics with poor control were given supplementation with 20 grams of guar gum and 10 grams of wheat bran for two months; the bran was used in conjunction with the guar gum in order to increase palatability. The fiber was sprinkled over the food prior to eating.

The addition of fiber did cause some noteworth results. Urinary glucose excretion dropped from 30.5 grams to 8.3 grams in 24 hours, and fasting blood glucose fell 39 percent, from 301 milligrams per deciliter to 184 milligrams per deciliter. Furthermore, plasma cholesterol decreased 30 percent, from 277 milligrams per deciliter . to 193 milligrams per deciliter. The fiber also delayed gastric emptying. No significant change occurred in weight, insulin, serum triglycerides, high density lipoproteins or free fatty acids. Yet, in spite of the lowering of the four-hour glucose curve, there was no change in the postprandial glucose increments above the baseline. Thus, the delayed gastric emptying appeared to have no effect. This is probably the result of the method by which the fiber was added to the food. In general, the more thoroughly fiber is integrated into the food, the greater the effect it has (Ray et al., 1983).

A number of factors must be considered when attempting to predict the effect of a particular food on blood sugar. The type of fiber and the method of supplementation have been mentioned. Other factors affect glycemic response indirectly by influencing starch digestibility; these will be discussed only briefly in this context. One important factor is the physical form of the food (Jenkins et al., 1983; Thorne, Thompson and Jenkins, 1983). First of all, cooked starches tend to raise blood sugar and insulin higher than raw starches because cooking increases viscosity and splits the starch granules. Moist heat increases digestibility more than dry heat, as well as increasing protein quality. Length of cooking time may also be a factor. Secondly, particle size is a consideration. Grinding a food before cooking increases the glucose and insulin response more than grinding after cooking. Generally speaking, increased processing results in increased response.

Another factor affecting digestibility is the nature of the starch (Thorne et al., 1983). Amylopectin is digested more easily than amylose. Thus, foods high in amylopectin can be expected to raise blood sugar more than foods such as legumes, which are high in amylose. Protein/starch interaction is another consideration; removing the protein from wheat starch increased its digestibility. Finally, antinutrients other than fiber influence the digestibility of a food as well as glycemic response. These include enzyme inhibitors, phytates and lectins. Digestion of starch is inhibited by antinutrients in the gastrointestinal tract. These may also affect digestibility in cooked foods, although heat destroys some antinutrients.

In light of the information now available therefore, several researchers have asserted that the traditional exchange list used in diabetic diets should be revised to compensate for the varying glycemic responses of different foods. This glycemic response does not always correspond to the carbohydrate content, as is evident from the results reported. A leading researcher in this area is David J. A. Jenkins (Jenkins et al., 1980; Jenkins et al., 1981; Jenkins et al., 1983; Thorne et al., 1983). In one particular study he tested the glycemic responses of 62 common foods and sugars on five to ten healthy, fasting volunteers (Jenkins et al., 1981). Most portions provided 50 grams of carbohydrate, except in a few cases where that amount was too large to be consumed in the specified time period.

The standard of comparison was the glucose curve for 50 grams of glucose. The results for the various food groups were: vegetables - 70 percent; breakfast cereals - 65 percent; cereals and biscuits - 60 percent; fruit - 50 percent; dairy - 35 percent; and dried legumes - 31 percent. There were large differences in the responses not only between food groups but also between foods within the same group.

There appeared to be a negative relationship between glycemic response and fat and protein content. The reason for this is that fat delays gastric emptying, as mentioned previously, and protein stimulates insulin secretion. There did not appear to be a relationship between response and fiber or sugar, possibly because the sugar was primarily fructose. Also, the fiber was mostly wheat bran, which has less effect on glycemic response than do viscous fibers. Legumes (41 percent) had an amazingly small effect on blood sugar compared to that of cereal (59 percent) (Jenkins et al., 1981). Legumes contain larger amounts of amylose than other starches and are higher in antinutrients; they contain twice as much protein as cereals. These factors all contribute to the characteristic effect of legumes on blood glucose (Thorne et al., 1983).

The above information on the glycemic index of various foods is interesting and may be helpful in predicting metabolic responses to carbohydrate. However, the response is also influenced by other foods, such as fat, which are ingested simultaneously. Therefore, in predicting short-term and long-term responses to mixed meals, it appears unlikely that studies with single foods will have a major impact (Bierman, 1985).

## Considerations in Long-term Implementation of the Diet

One important concern with long-term consumption of a high fiber diet is the effect on vitamin and mineral status. Studies done on patients during the early weeks on a high fiber diet showed an increased fecal excretion of calcium, iron, magnesium and zinc

(Anderson, Midgley et al., 1979). However, one long-term study evaluated 15 diabetics who had followed high fiber diets for an average of 21 months. The subjects were consuming 25 to 35 grams of plant fiber per 1000 calories each day. Despite the high intake of fiber, average values for serum calcium, phosphorus, alkaline phosphatase, iron, total iron-binding capacity, magnesium and hemoglobin values were normal. Finally, indirect assessment of vitamins A, D, and K suggested that intake of these fat-soluble vitamins was adequate. It is interesting to note that serum magnesium levels were normal, even though hypomagnesemia is relatively common among diabetic persons (Anderson, Ferguson et al., 1980). Further testing using more sensitive methods of measuring vitamin and mineral status is necessary to accurately determine the effects of a high fiber diet. However, it appears that there may be adaptive measures which enhance the efficiency of nutrient absorption over long periods of time.

The other major considerations with long-term consumption of a high carbohydrate, high fiber diet are the palatability of the diet and gastrointestinal side effects caused by a high fiber diet; both are important factors in patient acceptance and compliance. Palatability has not been a problem, especially when a variety of fiber-containing foods are used. The main difficulty patients have is restricting their intake of meat and fat (Anderson and Ward, 1978).

None of the subjects have complained of adverse side effects of gastrointestinal disturbances, according to Anderson, a leading researcher and proponent of high carbohydrate, high fiber, low fat diets for diabetics. Many experience an increased number of bowel movements, and so are no longer bothered with constipation. Most experience more flatulence. Overall, however, the diet appears to be well tolerated with minimal problems, and patient compliance is high (Anderson, 1980; Anderson et al., 1978).

## Summary of the Review of Literature

Diet has been the primary form of therapy ever since diabetes was first described as a disease, and throughout modern history carbohydrate restriction has been the preferred recommendation. Recently however, evidence has accumulated on the benefits of a high carbohydrate, high fiber, low fat diet for persons with diabetes. The American Diabetes Association published a statement in support of such a diet in 1971 and reaffirmed the statement in 1979. Other organizations and health professionals are now making similar recommendations.

A number of studies have been designed to evaluate the effects of high carbohydrate, high fiber, low fat diets; other studies have compared various types of fiber. In both cases results have been quite significant. In general, the carbohydrate content of the diet appears to have the greatest effect on plasma glucose levels and insulin requirements by improving the efficiency of the body in glucose metabolism and by increasing the number of insulin receptors. Fat content is also important, because fat decreases insulin sensitivity, blocks the uptake of glucose and raises blood lipid levels.

Finally, certain types of fiber have a significant hypoglycemic effect, praticularly in conjunction with a high carbohydrate, low fat diet. Viscous fibers are the most effective in this respect. Other factors also influence the response of blood sugar to fiber. These include the method of supplementation, starch digestibility, the physical form and the amount of preparation and processing of the food.

Even more significant than the effect on blood glucose control is the influence of fiber on blood lipids. Soluble fibers have been shown to effectively lower serum cholesterol levels. Insoluble fibers, on the other hand, are more effective in reducing serum triglyceride levels, especially in patients with hypertriglyceridemia.

Finally, in the long-term use of a high carbohydrate, high fiber, low fat diet several factors must be considered, including the effect of fiber on vitamin and mineral status as well as the palatability and gastrointestinal side effects. Initial studies evaluating vitamin and mineral status have found no detrimental nutritional effects on subjects consuming the recommended diet for almost two years. Palatability does not appear to be a problem, and reported gastrointestinal disturbances have been minor.

Generally, patient tolerance and compliance to a high carbohydrate, high fiber, low fat diet appear to be high. Problems and side effects of the diet are minimal, whereas the demonstrated benefits on serum blood glucose and lipids are often dramatic. Therefore, the diet currently recommended by the American Diabetes Association and the American Dietetic Association should result in greater glycemic control and a decrease in diabetic complications.

# CHAPTER III

# METHODOLOGY

The purpose of this study was to determine, in part, the effectiveness of hospital diabetes education classes by providing a follow-up to patients who attended these classes. This was accomplished by measuring the level of recall of basic nutrition information with a simple questionnaire as well as by assessing the adequacy of the subjects' diets. In the nutritional assessment nutrient intake levels were compared to the Recommended Dietary Allowances and to current recommendations by the American Diabetes Association and the American Dietetic Association. Fasting blood sugar was also monitored.

## Subjects

In this study five insulin-dependent and eight non-insulin-dependent diabetic subjects who had recently completed a diabetes education class at either St. Anthony Hospital in Oklahoma City or St. Francis Hospital in Tulsa, Oklahoma were involved. All six males and seven females consented to participate when contacted by a dietitian and the researcher. The study was presented as follow-up to the instruction received in the hospital classes. These classes covered basic information about diabetes mellitus and various aspects of living with the disease. Some of the topics included were insulin and oral hypoglycemic agents, complications of diabetes, home monitoring of blood glucose, basic nutrition, the diabetic meal plan, reading food labels and information about carbohydrates, fat, fiber and alcohol in the diabetic diet.

## Data Collection

The duration of the study was three weeks. During this time, participants were asked to keep a complete daily record of dietary intakes and also of daily fasting blood glucose levels. Monitoring of blood sugar levels occurred at least once a day and was conducted at home by the patients, most of whom used the Accu-check II. This is a blood glucose monitor which uses a reagent test strip to give a digital reading of current blood sugar levels. Subjects were requested to return their dietary record forms at the end of each week so that any questions about food intake or the record keeping could be clarified if necessary. The dietary record forms were provided by the hospital dietitian along with a sheet of printed instructions. (See Appendix A.) All other questions or problems were handled individually through the hospital dietitians who functioned as consultants throughout the study.

At the beginning of the three weeks each participant also completed a brief questionnaire to determine their understanding of basic nutrition information pertinent to the study and presented earlier in the classes. The questionnaire included questions about saturated and unsaturated fats, simple and complex carbohydrate and dietary fiber. All of this material had been presented and discussed in the diabetes education classes by the teaching dietitian. Some questions dealing with the patient's compliance were also included. The questionnaires were evaluated by the researcher for comprehension both among individual subjects and by the group as a whole. A copy of the questionnaire is included in Appendix A.

The food records were analyzed using a microcomputer software program, Food Processor I (ESHA Corporation, copyright 1984). This software program combines nutritional analysis information from Handbook Eight and a number of other sources. Intakes of calories, protein, saturated and unsaturated fats, carbohydrate and dietary fiber were determined. Intakes of vitamins A, C, thiamin, riboflavin and cobalamin, as well as iron, calcium, phosphorus, potassium and magnesium were also calculated. This data was then compared to the Recommended Dietary Allowances using the same computer program. Comparison was also made to current dietary recommendations by the American Diabetes Association and the American Dietetic Association and to the diet plans calculated for each individual by their dietitian (American Diabetes Association, 1979). Finally, blood glucose control, as evidenced by average fasting blood sugar levels, was compared to the levels of intake of carbohydrate, fat and dietary fiber.

# CHAPTER IV

## RESULTS AND DISCUSSION

This study was planned to provide a useful follow-up to the hospital diabetes education classes, and information to accomplish this purpose has resulted. Twelve subjects provided diet records and fasting blood sugar readings for a three week period. Only seven subjects completed diet records and five completed fasting blood glucose measurements for all 21 days, but all 12 of these subjects provided at least partial records for both. A total of 229 daily diet records were analyzed. The questionnaire was completed by 13 participants, one of whom did not provide any information on dietary intake or blood sugar.

The mean age of the subjects was 50 years, with 13 years as the average length of time they had had diabetes. All of the subjects were Caucasian. Treatment for nine of the patients included insulin with diet, three used an oral hypoglycemic agent with diet, and one was treated with diet alone. Six of the participants were considered obese; the other seven were within 20 percent of their ideal body weight. Tables II and III provide the physical and clinical characteristics of the subjects. Data for the table was obtained from hospital records by the two dietitians in charge of diabetes education in the two respective hospitals.

TABLE II

PHYSICAL CHARACTERISTICS OF SUBJECTS

| Subject | Age (years) | Sex | Height | Weight (pounds) | Percent IBW |
|---|---|---|---|---|---|
| 1 | 67 | M | 5' 8" | 170 | 110 |
| 2 | 38 | M | 5' 7" | 178 | 120 |
| 3 | 48 | Fe | 5' 6" | 132 | 100 |
| 4 | 63 | Fe | 5' 7½" | 157 | 113 |
| 5 | 59 | M | 6' 0" | 250 | 140 |
| 6 | 58 | Fe | 5' 5" | 150 | 120 |
| 7 | 49 | Fe | 5' 2" | 150 | 136 |
| 8 | 57 | Fe | 5' 4" | 186 | 155 |
| 9 | 40 | M | 5'11" | 150 | 87 |
| 10 | 69 | M | 5' 8" | 173 | 112 |
| 11 | 32 | Fe | 5' 7" | 168 | 124 |
| 12 | 33 | M | 6' 3" | 197 | 100 |
| 13 | 38 | Fe | 5' ½" | 107 | 104 |

TABLE III

CLINICAL CHARACTERISTICS OF SUBJECTS

| Subject | Type of Diabetes[1] | Disease Duration (years) | Medication | Diet (total cal) |
|---|---|---|---|---|
| 1 | II | 18 | Insulin | 1800 |
| 2 | I | 24 | Insulin | 1800 |
| 3 | I | 29 | Insulin | 1500 |
| 4 | II | 15 | Insulin | 1200 |
| 5 | II | unknown | Oral Agent | 1500 |
| 6 | II | 1 mo. | Oral Agent | 1200 |
| 7 | II | 1 | Oral Agent | 1000 |
| 8 | II | 15 | Diet | 1000 |
| 9 | I | 4.5 | Insulin | 2800 |
| 10 | II | 8.5 | Insulin | 1500 |
| 11 | I | 10 | Insulin | 1200 |
| 12 | II | 2 mo. | Insulin | 2500 |
| 13 | I | 34 | Insulin | 800 |

[1]
I - Insulin-dependent
II - Noninsulin-dependent

## Dietary Intakes

The dietary intake records were analyzed using the student's t-test (with a significance level of .05) to determine whether the self-selected diets consumed by the subjects met two-thirds or more of the Recommended Dietary Allowances. These levels were met for most nutrients. (See Figure 1.) An average of at least two-thirds of the Recommended Dietary Allowances for protein, vitamins A, $B_1$,$B_2$, $B_{12}$ and C and for calcium, iron, magnesium and phosphorus was met by nine of more of the 12 subjects who provided dietary records. Eight averaged a potassium intake of at least two-thirds of a level considered "safe and adequate". Seven participants also consumed an average of 100 percent or more of the Recommended Dietary Allowances for all of those nutrients except magnesium. In the other five subjects, at least three consumed less than 100 percent of the recommended levels of protein, vitamins $B_1$ and $B_2$, calcium and iron. Mean intakes of calories, carbohydrate, dietary fiber, total fat, unsaturated fat, potassium and magnesium for the participants as a group were below 100 percent of the recommended level. (Intake of unsaturated fat was 97.49 percent of the recommended level.) The mean intakes of vitamins A, $B_1$, $B_{12}$ and C and of iron and phosphorus for the 12 subjects, on the other hand, were all above 120 percent of the recommended amounts. In fact, the mean percentages of vitamins A and C are 322.5 and 210, respectively. Of course, intakes of individual nutrients tended to vary significantly from day to day. Table IV in Appendix B provides a list of recommended and actual nutrient intakes for the subjects. (See Table

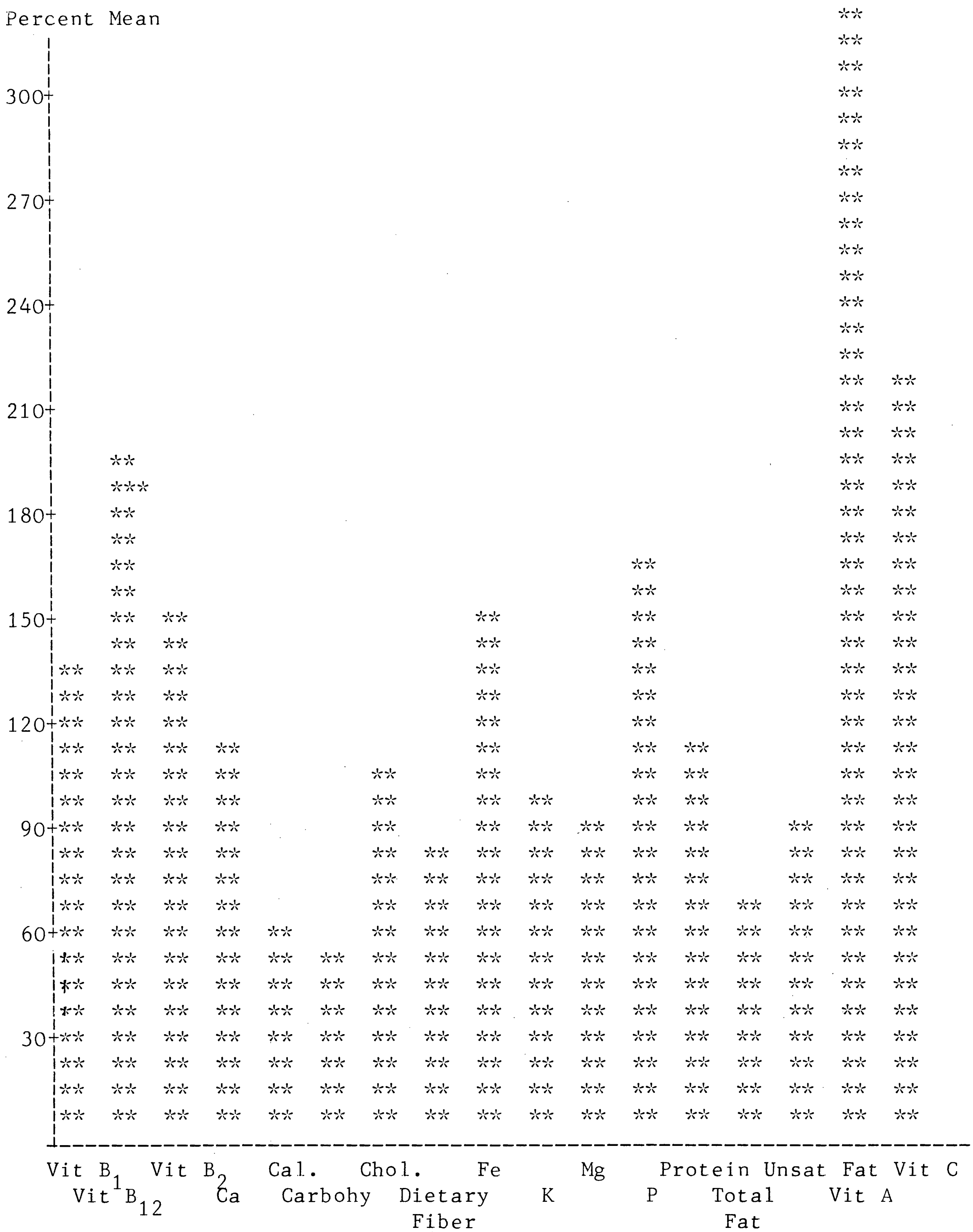


Figure 1. Mean Percentages of Recommended Dietary Allowances for All Individuals

Recommendations for caloric intake are based on height, weight and activity level. Carbohydrate represents 58 percent of the total caloric intake, protein 12 percent and fat 30 percent.

V in Appendix B for the standard deviations of the nutrient intakes.)

The differences between individual dietary intakes and recommended intakes were also analyzed to determine any differences between males and females and between those who attended classes at the two hospitals. Subjects 1, 2, 5, 9, 10 and 12 were males; subjects 3, 4, 6, 7, 8, 11 and 13 were females. (Subject 13 did not provide information on dietary intake.) There was no statistical difference according to sex for most nutrients - protein, vitamin $B_2$, vitamin C, carbohydrate, cholesterol, unsaturated fat, calcium, iron, phosphorus and potassium. Intakes of the other nutrients - calories, dietary fiber, vitamin A, vitamin $B_1$, vitamin $B_{12}$, total fat and magnesium - were all lower among the female subjects. Levels of vitamins A and $B_{12}$ were still above 100 percent of the Recommended Dietary Allowance for both sexes, however. There were differences in intakes of subjects from the two hospitals. Subjects one through ten were from Hospital One and subjects 11 through 13 were from Hospital Two. Intakes of only two nutrients - dietary fiber and vitamin C - were substantially different. The mean intakes of these nutrients were higher for subjects from Hospital Two. Nevertheless, both groups met more than two-thirds of the recommended levels of dietary fiber and vitamin C. It should be noted that calculations were based on only two subjects from Hospital Two.

The results obtained from the study clearly indicate that the majority of the subjects met or exceeded two-thirds of the Recommended Dietary Allowances for major vitamins and minerals. There is reasonable assurance on the basis of this study that patients who have completed hospital diabetes education classes will consume diets that provide at least two-thirds of the Recommended Dietary Allowances for major nutrients. This occurs even in those persons following low calorie meal plans. Furthermore, it appears that one-half or more of the patients will consume diets that provide 100 percent of the Recommended Dietary Allowances for most major vitamins and minerals. However, most of the participants in the study chose diets that did not provide 100 percent of the recommended amounts of magnesium and potassium. It would be beneficial for these individuals to increase food sources of those nutrients in their diets.

The mean caloric intake was low (1443.20 kcal.) because all but three of the subjects were following meal patterns designed for weight loss. One subject was following a meal pattern designed for weight gain. The mean daily carbohydrate intake among the subjects was 174.72 grams; the average intake of dietary fiber was 24.91 grams Participants averaged 79.92 grams of protein each day. Total fat consumed averaged 54.05 grams daily, and 29.24 grams of that was unsaturated. Daily cholesterol consumption averaged 304.11 grams. Mean carbohydrate intake among the subjects was 47.47 percent of total caloric intake, protein was 20.45 percent, total fat was 32.08 percent and unsaturated fat was 17.66 percent. (See Figure 2.)

Intakes for each of the participants were compared to the dietary guidelines established by the American Diabetes Association and the American Dietetic Association for persons with diabetes. These guidelines state that of the total calories consumed, carbohydrate should comprise 50 to 60 percent, protein 12 to 20 percent and

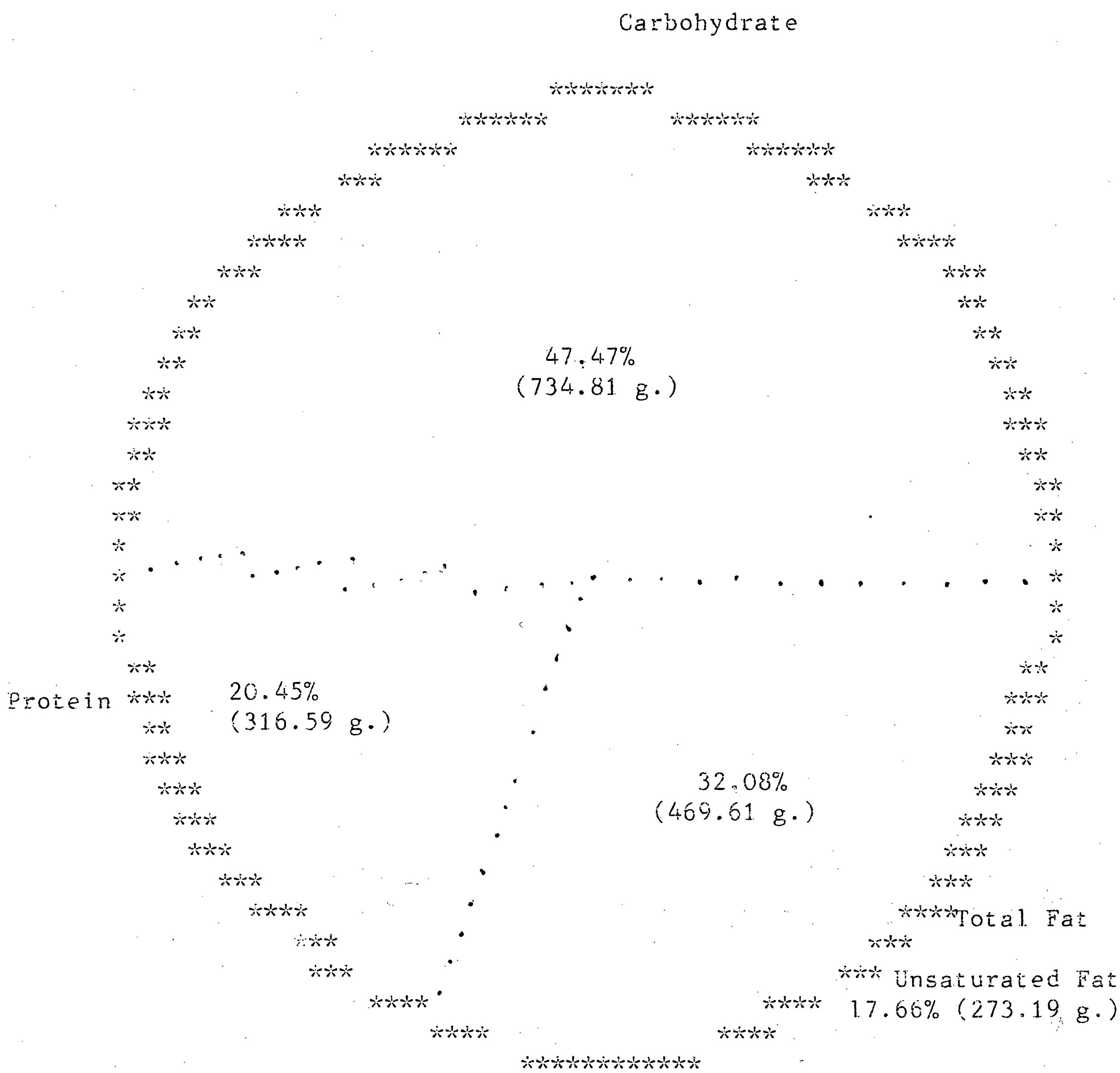


Figure 2. Nutrient Sources of Calories For All Individuals

fat 20 to 38 percent. Unsaturated fats should provide approximately ten percent of the calories. In comparison, in this study carbohydrate intake was below the recommended level, or 44.82 percent, in seven of the participants and averaged 47.47 percent in the group overall. Protein consumption was a little above 20 percent (22.9 percent) in five subjects and 19.02 percent in the remainder; total fat was within the recommendation for all but one individual. All of the subjects obtained more than ten percent of their caloric intake from unsaturated fat, ranging from 13.33 to 22.55 percent. Figure 3 shows a breakdown of caloric intakes for each individual.

In light of the low average caloric intake, it is anticipated that subjects who are overweight will reduce their weight. They appear to be complying with their individualized meal plans which specify lowered caloric intake. Since carbohydrate intake only averaged about 47 percent, it should be increased to meet the recommended level, preferably by increasing high fiber foods and by decreasing dietary fat. Mean consumption of dietary fiber was 24.91 grams; the range of intake was 12.35 grams to 50.76 grams. Seven of the subjects consumed 20 or more grams of dietary fiber. This amount is equivalent to the national average. Further increases in intake of dietary fiber would most likely be beneficial. Studies such as those already cited indicate that increasing dietary fiber and complex carbohydrates would help maintain blood glucose control.

Mean protein intake at 20.45 percent of the total calories is slightly higher than recommended but is consistent with Amercian food selection patterns. Total fat consumption is within the recommended

```
100  + TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT
P      | TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT
E      | TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT
R      | TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT C-Carbohydrate
C   90 + TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT P-Protein
E      | TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT T-Total Fat
N      | TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT
T      | TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT
    80 + TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT TTT
       | TTT TTT TTT PPP TTT TTT TTT TTT TTT TTT TTT TTT
O      | TTT TTT TTT PPP TTT TTT TTT PPP TTT TTT TTT TTT
F      | TTT TTT TTT PPP TTT TTT TTT PPP TTT TTT PPP TTT
    70 + PPP TTT PPP PPP TTT TTT PPP PPP TTT PPP PPP TTT
       | PPP TTT PPP PPP PPP TTT PPP PPP PPP PPP PPP PPP
C      | PPP PPP PPP PPP PPP TTT PPP PPP PPP PPP PPP PPP
A      | PPP PPP PPP PPP PPP TTT PPP PPP PPP PPP PPP PPP
L   60 + PPP PPP PPP PPP PPP TTT PPP PPP PPP PPP PPP PPP
O      | PPP PPP PPP PPP PPP TTT PPP PPP PPP PPP PPP PPP
R      | PPP PPP PPP CCC PPP PPP PPP CCC PPP PPP PPP PPP
I      | PPP PPP PPP CCC PPP PPP PPP CCC PPP CCC PPP PPP
E   50 + PPP PPP PPP CCC PPP PPP CCC CCC PPP CCC CCC PPP
S      | CCC CCC PPP CCC PPP PPP CCC CCC CCC CCC CCC CCC
       | CCC CCC PPP CCC CCC PPP CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC PPP CCC CCC CCC CCC CCC CCC
    40 + CCC CCC CCC CCC CCC PPP CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
    30 + CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
    20 + CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
    10 + CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
       | CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC CCC
      -+---------------------------------------------------------------
         1   2   3   4   5   6   7   8   9   10  11  12
```

Figure 3. Percentage of Caloric Intake from Cabohydrates, Protein and Fat

range. Further reduction of fat could aid in controlling blood sugar, as has been reported earlier (Anderson, 1980; Anderson and Ward, 1979; Collier et al., 1984; Wavpotich, 1984). The percentage of fat from unsaturated sources was significantly higher than recommended in the guidelines and should be reduced. However, it is probably better for persons with diabetes to err on the side of a higher intake of unsaturated fats rather than saturated fats, because of the relationship between saturated fat and heart disease. Cholesterol intake was only slightly above the recommended level.

## Fasting Blood Sugar

Fasting blood sugar measurements were a part of the subjects' medical treatment and were considered in regard to compliance with meal plans for individual subjects as well as a means of monitoring metabolic control. Twelve of the participants provided these test results which were then scrutinized for indications of good control along with adequate dietary intakes. The number of blood sugar measurements recorded varied greatly among the subjects. Eight participants provided records for over 14 days, but measurements for two individuals were only available for four days. (See Table VI.) Apparently some of the subjects do not check their blood sugar daily, in spite of instructions from their doctor to do so. Others may have measured fasting blood glucose but failed for some reason to record it.

Mean fasting blood glucose levels ranged from 69 to 211 milligrams per deciliter. Three subjects averaged fasting blood sugar

TABLE VI

FASTING BLOOD GLUCOSE MEASUREMENT

| Day | Subject 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 167 | 157 | 138 | 189 | 106 | 135 | – | 99 | 146 | 102 | 219 | 99 |
| 2 | 184 | 187 | 151 | 213 | 66 | 142 | 177 | 107 | 139 | 255 | 130 | 71 |
| 3 | 184 | 136 | 163 | 184 | 50 | 141 | 150 | 106 | 178 | 155 | 50 | 78 |
| 4 | 187 | 63 | 266 | 186 | 33 | 134 | 131 | 113 | 251 | 184 | 262 | 85 |
| 5 | – | 75 | 233 | – | 48 | 141 | 149 | – | 163 | 146 | 60 | 97 |
| 6 | – | 88 | 131 | – | 88 | 124 | 133 | – | – | 130 | 200 | 88 |
| 7 | – | 185 | 227 | – | 79 | 169 | 86 | – | 94 | 235 | 158 | 125 |
| 8 | 174 | 63 | 116 | – | 44 | 175 | 135 | – | 68 | – | 48 | 86 |
| 9 | 183 | 279 | 95 | – | 33 | 147 | 176 | – | 78 | – | 228 | 66 |
| 10 | 184 | 86 | 117 | – | 56 | 164 | 176 | – | 94 | – | 28 | 67 |
| 11 | 186 | 159 | 161 | – | 53 | 134 | 129 | – | 164 | 246 | 40 | – |
| 12 | 164 | 196 | 83 | – | 45 | 132 | 145 | – | 74 | – | 30 | – |
| 13 | 153 | 135 | 92 | – | 90 | 135 | 112 | – | 82 | – | 128 | – |
| 14 | 175 | 76 | 88 | – | 29 | 131 | 100 | – | 123 | – | 48 | – |
| 15 | 165 | 256 | 180 | – | 56 | 134 | 120 | – | – | 235 | 200 | – |
| 16 | 180 | 84 | 117 | – | 70 | 137 | 133 | – | – | 263 | 228 | – |
| 17 | 181 | 115 | 102 | – | 105 | 159 | 142 | – | – | 207 | 68 | – |
| 18 | 179 | 113 | 141 | – | 76 | 137 | 149 | – | – | 225 | 38 | – |
| 19 | 177 | 110 | 135 | – | 102 | 136 | 130 | – | – | 300 | 90 | – |
| 20 | 175 | 284 | 184 | – | 117 | 131 | 173 | – | – | 269 | 291 | – |
| 21 | 174 | 90 | 51 | – | 110 | 147 | 120 | – | – | 220 | 78 | – |
| Mean | 176 | 139 | 141 | 193 | 69 | 142 | 138 | 106 | 127 | 211 | 123 | 86 |

Measurements taken in milligrams per deciliter.

levels below 110 milligrams per deciliter, and nine averaged levels below 150 milligrams per deciliter. One subject had mean fasting levels above 200 milligrams per deciliter. Fasting blood glucose should ideally be less than 110 milligrams per deciliter. (See the standard deviation table - Table VII - in Appendix B.) Some of the fasting blood sugar measurements such as those of subjects 1, 5 and 8 did not fluctuate greatly from day to day. Other readings however, such as those of subjects 2, 3 and 11, differed by over 200 milligrams per deciliter. A lack of wide fluctuations does not necessarily indicate good blood sugar control; nevertheless, it is a helpful step toward achieving that goal.

Therefore, fasting blood glucose was well controlled in three of the subjects and moderately high in six. The other three had high fasting blood sugar levels, averaging over 175 milligrams per deciliter. There was no difference according to sex; two out of three of the subjects in both the well controlled group and the high group were males. When mean fasting blood glucose levels were compared to mean intakes of carbohydrate, dietary fiber and total fat using the F test, no significant relationship was found. Figure 4 provides the mean fasting blood glucose level for each subject in comparison to their average intake of carbohydrate, dietary fiber and total fat.

However, it can be seen from Figure 4 that average carbohydrate intake tended to be higher in the three subjects with fasting blood sugar levels below 110 milligrams per deciliter. (201.87 grams carbohydrate) than in those three subjects with fasting blood glucose levels above 150 milligrams per deciliter (167.84 grams).

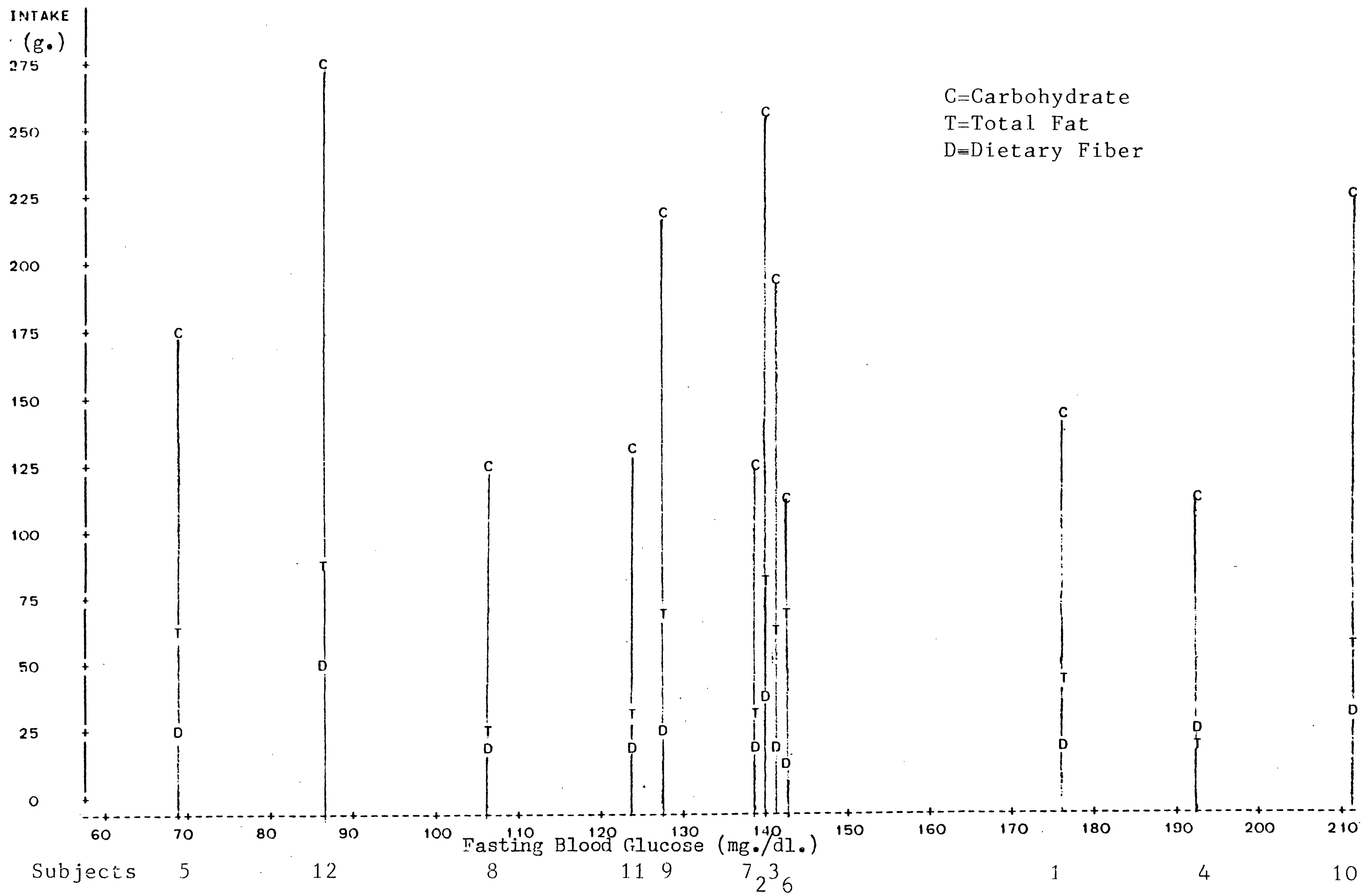


Figure 4. Dietary Intakes Compared to Fasting Blood Glucose Measurements

Furthermore, the average consumption of dietary fiber in three subjects with acceptable fasting blood sugar levels was 32.45 grams compared to 23.00 grams in the three subjects with high fasting blood sugar levels. Thus it appears that a correlation may exist, and the higher intakes of carbohydrate and dietary fiber attributed to better fasting blood glucose control for these subjects. Nevertheless as previously noted, no significant statistical relationship was found between fasting blood sugar levels and intake of carbohydrate, dietary fiber or fat. However, consistent daily records of fasting blood glucose levels were not available for a number of the participants. Also, the diets were self-selected and generally did not contain the high levels of carbohydrate and dietary fiber which have been shown to have an effect in lowering blood glucose levels.

## Nutrition Knowledge

The questionnaire on nutrition knowledge (Appendix A) was completed by all 13 participants. (As previously noted, one subject answered only the questionnaire while the other 12 provided dietary records and fasting blood sugar measurements in addition to the questionnaire.) Questions one through four covered basic information on fats, questions five through seven dealt with carbohydrates and questions eight through ten dealt with dietary fiber. Questions 11 and 12 were subjective questions about dietary compliance. Overall scores on the questionnaire ranged from 61.36 to 93.18 percent of a possible 100 percent; the mean score was 77.27 percent. There was no significant difference in the questionnaire results between males and females or between the participants from the two hospitals either in the overall scores or the scores on each section.

In answering the questions on fats, most of the subjects correctly differentiated between saturated and unsaturated fats and understood the reasons for limiting fat in the diet. Most sources of saturated fat were correctly identified, except for doughnuts and french fries, and most subjects correctly identified foods which contain hidden fat. (See Figures 5 and 6.)

There appeared to be some confusion about the differences between simple and complex carbohydrates and which one is restricted in the diabetic diet. These questions were missed by one-third to one-half of the respondents. When identifying foods high in complex carbohydrates, most were correctly identified by over one-half of the subjects - these were oatmeal, whole wheat bread, bran muffins, white bread and brown rice. However, only three respondents considered raw carrots to be high in complex carbohydrates, while seven incorrectly thought blueberry muffins to be a good source. (See Figure 7.)

The questionnaire helped to identify areas in which the subjects were familiar with nutrition subject matter. In general, the questions on fats were correctly answered. However, five respondents could not identify which type of carbohydrate, simple or complex, is limited in the diabetic diet (Question 6), and eight failed to identify statements which differentiated between these two types of carbohydrate (Question 5). Thus, it appears that the subject of carbohydrates should be emphasized more strongly or explained more clearly in the diabetes education classes.

```
Number of Subjects
                   ***            ***
                   ***            ***
    12 +           ***            ***
       |           ***            ***            ***
       |           ***            ***            ***
    10 +           ***            ***            ***
       |           ***            ***            ***
       |           ***            ***            ***
     8 +           ***            ***  ***       ***
       |           ***            ***  ***       ***
       |           ***            ***  ***       ***
     6 +           ***       ***  ***  ***       ***
       |           ***       ***  ***  ***       ***
       |           ***       ***  ***  ***       ***
     4 +           ***       ***  ***  ***       ***
       |           ***       ***  ***  ***       ***
       |           ***       ***  ***  ***       ***
     2 +           ***       ***  ***  ***       ***
       |           ***       ***  ***  ***       ***
       |           ***       ***  ***  ***       ***
      -+-------------------------------------------------
        Peanut Oil     Bread     Bacon   Pinto Beans
                Hamburger  Doughnuts  French     Cheese
                                      Fries
                              Foods
```

Figure 5. Responses to Question 2: Food Sources of Saturated Fat

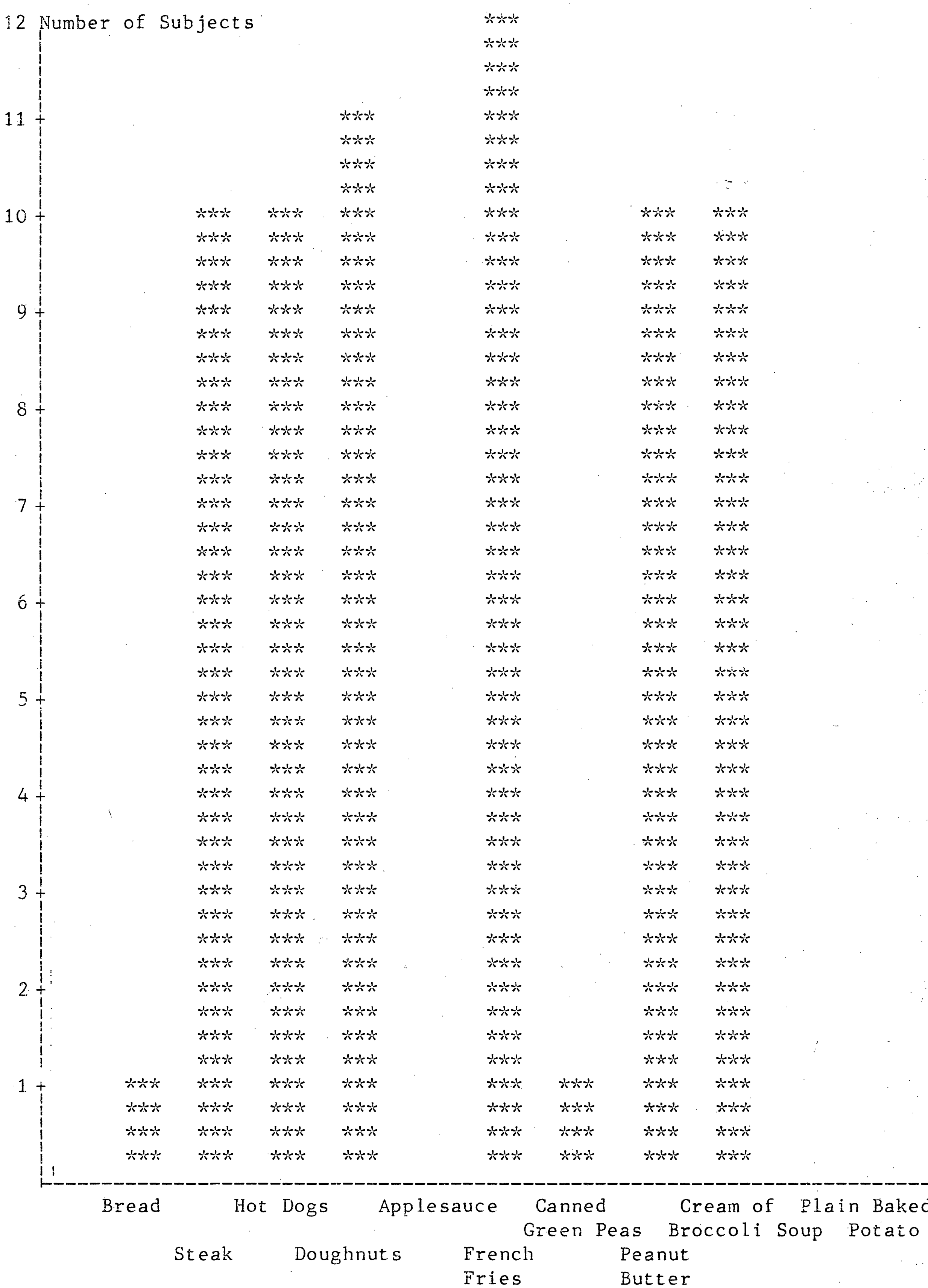


Figure 6. Response to Question 3: Food Sources of Fat

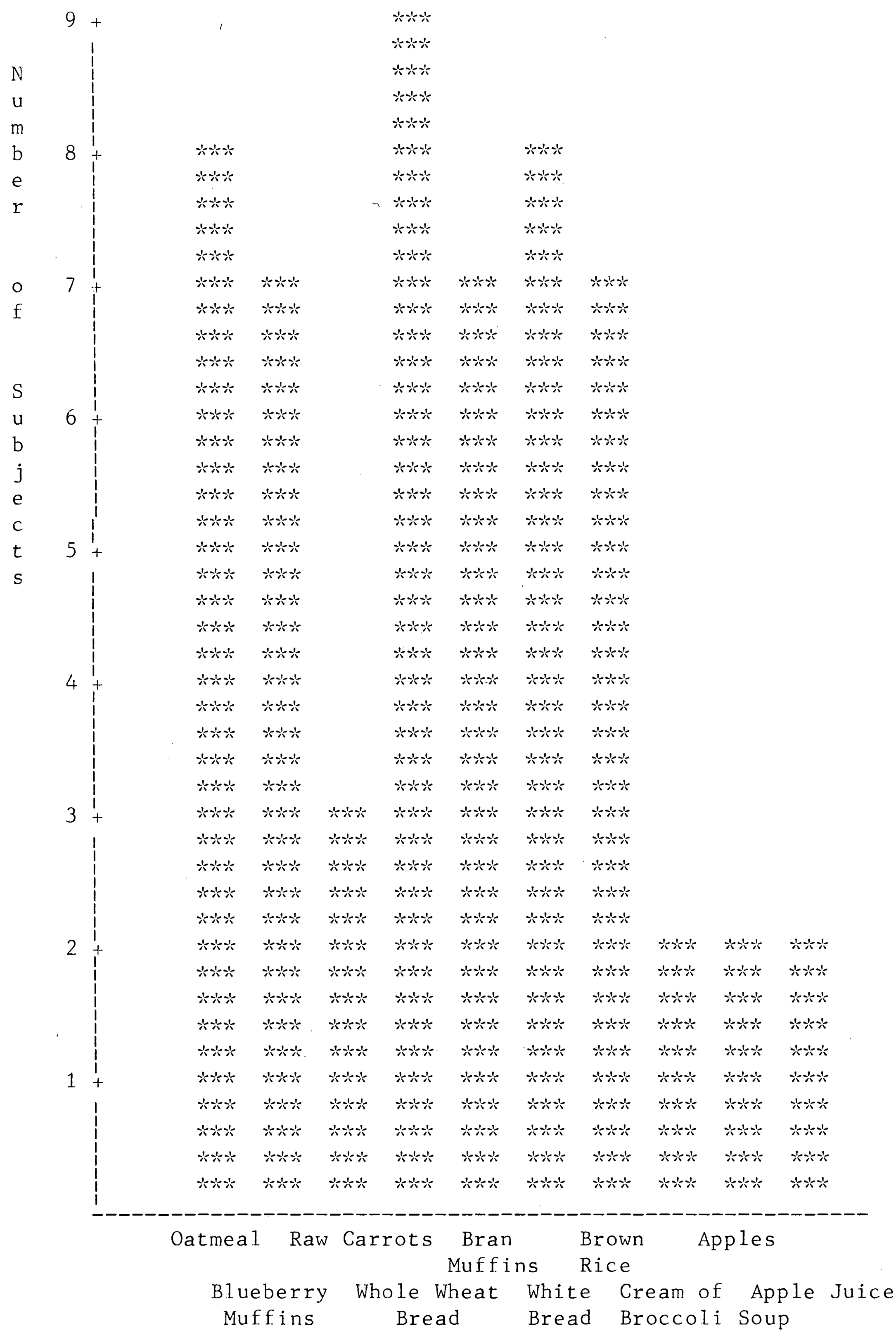


Figure 7. Response To Question 7: Food Sources of Complex Carbohydrates

In regard to dietary fiber, most of the fiber-containing food sources were properly identified by nine or more of the respondents. (See Figure 8). None identified roast beef as a source, which might have been expected since the term "meat fiber" is often used. On the other hand, seven identified grapes as a good source of dietary fiber, while eight of the respondents failed to recognize pinto beans as an excellent source. This source of fiber is another point which should be emphasized in the classes, particularly in light of the effect of beans on hypercholesterolemia. Beans are inexpensive, widely available and versatile in menus.

All of the respondents were familiar with recommendations concerning increasing levels of dietary fiber. These recommendations apply in several disease conditions as a possible preventive factor. The percentage of subjects indicating familiarity with recommendations in relation to the following diseases were: cancer - 69.2 percent; constipation - 61.5 percent; diabetes - 61.5 percent; other disease conditions - 30.8 percent. Information on the benefits of dietary fiber in relation to diabetes was included in the hospital nutrition classes. When asked how likely they were to increase their personal intake of dietary fiber, 15.4 percent indicated that they were likely and 84.6 percent indicated that they were very likely to increase fiber consumption.

The last two questions concerned compliance to a diet. In assessing the importance of following the diet designed by the doctor or dietitian, 7.7 percent indicated that it was important, and the remaining 92.3 percent considered it to be very important. Concerning

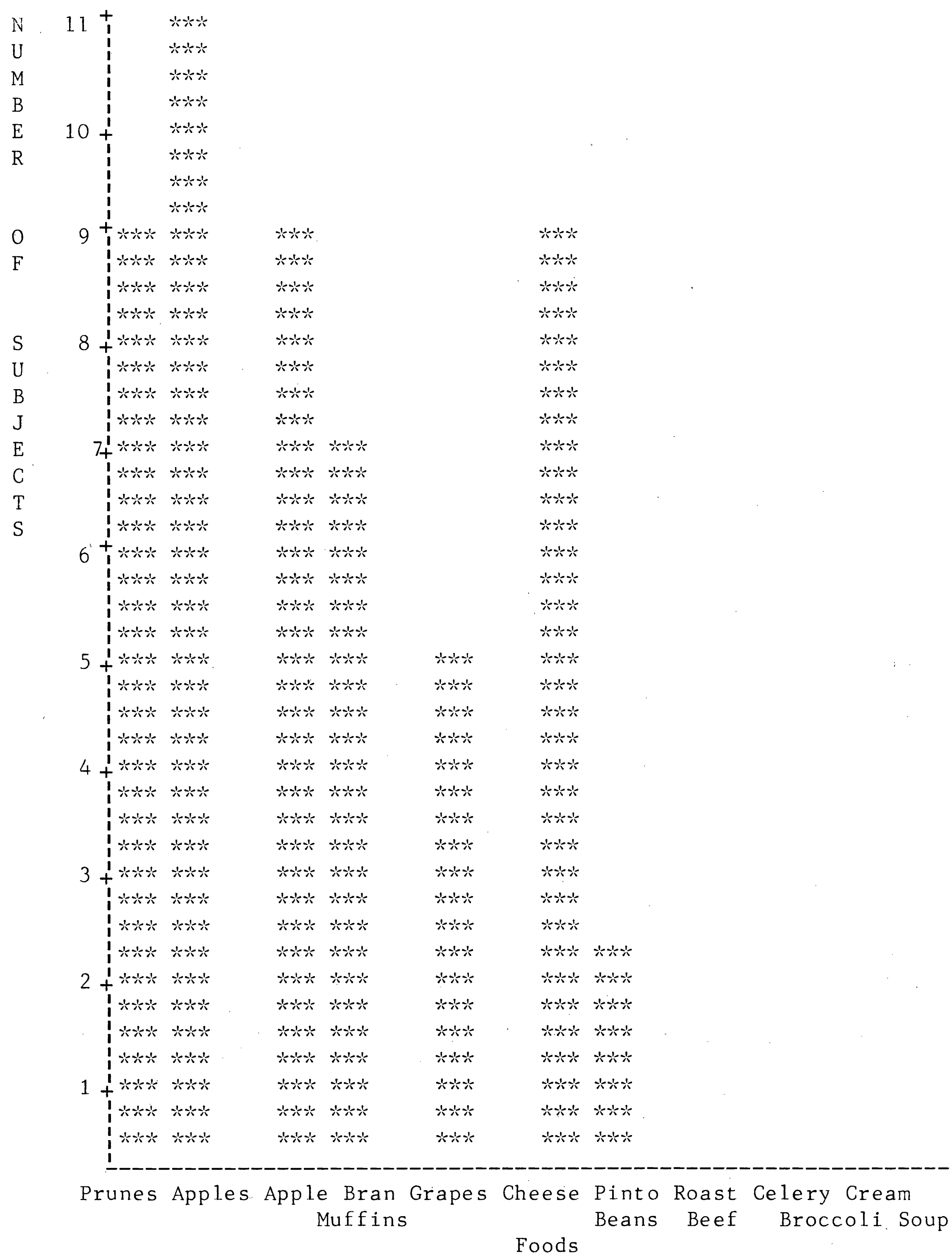


Figure 8. Responses to Question 9: Food Sources of Dietary Fiber

their personal compliance to that diet, 42.9 percent felt that they followed their diet well, while 57.1 percent felt that they followed it very well. In light of the results on dietary intakes, the assessment of the subjects generally appears to be acccurate.

Finally, dietary intake of carbohydrate, dietary fiber and fat by each subject was compared to their answers on the appropriate section of the questionnaire - questions five through seven, eight through ten and one through four, respectively. This data was analyzed using the F test. No significant statistical relationship was found. However, nutrition knowledge will affect the diet to some degree, and it is likely that over time the diet will continue to conform more closely to the nutrition knowledge obtained.

The results of this study demonstrate the value of the diabetes education classes provided by the hospitals. The diets of the subjects provided most major nutrients and generally met dietary recommendations. Compliance among the subjects was good. References cited previously indicate that compliance in the absence of instruction is not good. Furthermore, the results of the questionnaire indicate that the subjects understand some of the concepts basic to nutrition and to good diet planning. The scores on the questionnaire, which to some degree indicate the level of comprehension of the concepts discussed, would undoubtedly have been lower had the subjects not attended the classes. Therefore, the results obtained from this study indicate that diabetes education classes are an important asset in successfully treating diabetic patients.

# CHAPTER V

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## Summary and Conclusions

This study was designed to evaluate the dietary intakes and basic nutrition understanding of persons with diabetes who had recently completed hospital diabetes education classes and to assess their level of compliance to recommended meal plans. The study was to serve as a follow-up to the hospital classes and an assessment of their adequacy. All of the subjects met or exceeded two-thirds of the Recommended Dietary Allowances for most major nutrients, and compliance appeared to be good. In general, the dietary intakes of the subjects did meet the recommendation for carbohydrate, protein and fat intake, although carbohydrate consumption was a little low. The subjects consumed an average of 47.47 percent of their total calories from carbohydrate, 20.45 percent from protein and 32.08 percent from fat. The recommended amounts are 50 to 60 percent of the calories from carbohydrate, 12 to 20 percent from protein and 20 to 38 percent from fat. Mean intake of dietary fiber was 24.91 grams a day, equivalent to or slightly above the national average. The average cholesterol intake (304.11 grams) was slightly above the recommended level of 300 grams a day. Only one-fourth of the subjects had mean fasting blood glucose levels below 110 milligrams per deciliter, which is considered good fasting blood sugar control. Another quarter of the subjects had high fasting blood glucose levels, over 175 milligrams per deciliter.

Results from the questionnaire indicated some basic understanding of saturated and unsaturated fats and dietary fiber. There was less understanding, however, about simple and complex carbohydrates. All of the participants recalled recommendations for increasing fiber in the diet and indicated a willingness to increase their own intake. Finally, the subjects all indicated that they had a high level of compliance to their individual menu plan, and this assessment appears to be correct.

## Recommendations for Further Research

There are a number of possibilities for future investigations in this area. First of all, this study could be replicated with a larger number of subjects. Secondly, a comparison could be made of the level of compliance among diabetic persons who had completed hospital diabetes education classes and those who had not attended such classes. Another area of interest would be to determine whether any relationship exists between levels of intake of carbohydrate, dietary fiber and fat in self-selected diabetic diets and fasting and postprandial blood glucose. Such a study could test for a relataionship between average blood sugar levels and fluctuations in blood sugar. Finally, further research to assess the extent to which good blood glucose control might affect the long-term development of diabetic complications would be invaluable.

The results of the study presented in this thesis indicate the value of hospital diabetes education classes and should provide useful feedback for diabetes educators in planning nutrition education and meal planning classes. The data showing the degree of compliance to recommended dietary intakes provides indication of further needed areas of emphasis, and the information on the extent of blood glucose monitoring is of importance to medical supervision of the subjects. It is hoped that this and other studies will provide information which can be practically applied to benefit all diabetic individuals.

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# APPENDIX A

# PRINTED MATERIALS FOR SUBJECTS

## INSTRUCTIONS FOR STUDY PARTICIPANTS

1. Answer the participant questionnaire and return it to Kaye Fitz, Dietary Department, St. Anthony Hospital.

2. For a period of three weeks, keep a detailed record of all foods eaten, using the forms provided. Write down both the type and amount of the foods eaten. Try to eat as you normally do.

3. During this same time period, write down the time and reading each time you measure your blood sugar. Your fasting blood sugar should be checked daily. Use the same forms as above.

4. Return the food record forms to Kaye Fitz at the end of each week.

5. Should you have any questions about the study, please call Kaye at 272-6123.

6. Results of the study will be available if you are interested. A corrected copy of your questionnaire will also be returned to you, if you would like to have a copy.

Thank you so much for your cooperation and help.

PARTICIPANT QUESTIONNAIRE

1. Which statement is true of unsaturated fats? (Check one.)
   ____ Fats which are solid at room temperature and are usually found in animal products.
   ____ Fats which are liquid at room temperature and are usually found in plant products.
   ____ The type of fat most associated with heart disease.

2. Please check all of the following which you consider to be high in saturated fats:
   ____ peanut oil ____ bacon
   ____ hamburger meat ____ french fries
   ____ bread ____ pinto beans
   ____ doughnuts ____ cheese

3. Please check all of the following which you consider to contain hidden fats:
   ____ bread ____ french fries
   ____ steak ____ canned green peas
   ____ hot dogs ____ peanut butter
   ____ doughnuts ____ cream of broccoli soup
   ____ applesauce ____ plain baked potato

4. Why is it important not to eat a lot of foods high in fat? (Check all you think are true.)
   ____ Foods that are high in fat are often high in calories.
   ____ Foods high in fat are usually high in price.
   ____ A high fat diet may lead to heart disease, a common problem among diabetics.

5. Which statements best define complex starch or carbohydrate? (Check two.)
   ____ Found in whole grains such as whole wheat bread and brown rice.
   ____ Found in baked goods such as pastries, cakes, and pies.
   ____ Is quickly changed to sugar in the body.
   ____ Is slowly changed to sugar in the body.

6. Which type of carbohydrate is limited in a diabetic diet?
   ____ simple ____ complex

7. Please check all of the following which you consider to be food high in complex carbohydrates:
   ____ oatmeal ____ white bread

____ blueberry muffins
____ raw carrots
____ whole sheat bread
____ bran muffins
____ brown rice
____ cream of broccoli soup
____ apples
____ apple juice

8. Have you heard recommendations about increasing the level of fiber in your diet? ____ yes ____ no
If you answered yes to the last question, what was it in relation to? (Check all that are appropriate.)
____ cancer ____constipation ____ diabetes ____ other

9. Please check all of the following which you consider to be high fiber foods:
____ prunes
____ apples
____ apple juice
____ bran muffins
____ grapes
____ cheese
____ pinto beans
____ roast beef
____ celery
____ cream of broccoli soup

10. If a diet high in fiber were shown to help control diabetes, how likely would you be to increase the fiber in <u>your</u> diet?
____ very unlikely ____ unlikely ____ likely ____ very likely

11. How important do you feel it is to follow the diet you were given by the doctor or dietitian?
____not at all ____ not much ____ important ____ very important

12. How well do you feel that <u>you</u> follow the diet you were given?
____ not at all ____ not much ____ well ____ very well

# APPENDIX B

## INTAKE AND STANDARD DEVIATION TABLES

TABLE IV

NUTRIENT INTAKES: ACTUAL AND RECOMMENDED

| Nutrient | Subject's Intake | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | |
| | Actual | Rec. | Actual | Rec. | Actual | Rec. | Actual | Rec. | Actual | Rec. | Actual | Rec. |
| Calories | 1226 | 1877 | 2052 | 2696 | 1686 | 2149 | 753 | 2088 | 1498 | 2267 | 1324 | 1957 |
| Protein | 69 | 56 | 94 | 81 | 129 | 64 | 51 | 63 | 88 | 68 | 63 | 59 |
| Dietary Fiber[1] | 17 | 30 | 38 | 30 | 18 | 30 | 23 | 30 | 28 | 30 | 12 | 30 |
| Vitamin A | 10726 | 5000 | 3283 | 5000 | 4632 | 4000 | 4466 | 4000 | 9757 | 5000 | 6851 | 4000 |
| Vitamin $B_1$ | 1.1 | 1 | 3.1 | 1.3 | 1.2 | 1.1 | 1.1 | 1 | 2.6 | 1.1 | 1 | 1 |
| Vitamin $B_2$ | 1.6 | 1.2 | 3.9 | 1.6 | 2.1 | 1.3 | 1.5 | 1.3 | 3.4 | 1.4 | 1.3 | 1.2 |
| Vitamin $B_{12}$ | 4.2 | 3 | 12.2 | 3 | 5.3 | 3 | 3.4 | 3 | 11.4 | 3 | 4.7 | 3 |
| Vitamin C | 93 | 60 | 182 | 60 | 142 | 60 | 92 | 60 | 114 | 60 | 54 | 60 |
| Carbohydrate | 144 | 272 | 257 | 391 | 192 | 312 | 110 | 303 | 175 | 329 | 114 | 284 |
| Cholesterol | 110 | 300 | 464 | 300 | 469 | 300 | 104 | 300 | 245 | 300 | 295 | 300 |
| Unsat. Fat | 27 | 21 | 44 | 30 | 29 | 24 | 11 | 23 | 31 | 25 | 35 | 22 |
| Total Fat | 44 | 63 | 84 | 90 | 62 | 72 | 19 | 70 | 60 | 76 | 69 | 65 |
| Calcium | 653 | 800 | 1275 | 800 | 1252 | 800 | 343 | 800 | 805 | 800 | 558 | 800 |
| Iron | 13 | 10 | 21 | 10 | 11 | 18 | 13 | 10 | 34 | 10 | 12 | 10 |
| Magnesium | 210 | 350 | 562 | 350 | 276 | 300 | 251 | 300 | 359 | 350 | 194 | 300 |
| Phosphorus | 913 | 800 | 2312 | 800 | 1576 | 800 | 867 | 800 | 1528 | 800 | 884 | 800 |
| Potassium | 2574 | 3750 | 3869 | 3750 | 2790 | 3750 | 2042 | 3750 | 2817 | 3750 | 1764 | 3750 |

[1] Recommended amounts of dietary fiber are based on recommendations by the National Cancer Institute to consume 25 to 35 grams of dietary fiber a day (Trowell and Burkitt, 1986).

TABLE IV

Continued

| Nutrient | Subject's Intake 7 Actual | 7 Rec. | 8 Actual | 8 Rec. | 9 Actual | 9 Rec. | 10 Actual | 10 Rec. | 11 Actual | 11 Rec. | 12 Actual | 12 Rec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Calories | 994 | 2144 | 909 | 2233 | 1821 | 2432 | 1680 | 2531 | 1041 | 2486 | 2334 | 3031 |
| Protein | 54 | 64 | 49 | 67 | 96 | 73 | 81 | 76 | 60 | 75 | 125 | 91 |
| Dietary Fiber | 18 | 30 | 21 | 30 | 28 | 30 | 29 | 30 | 16 | 30 | 51 | 30 |
| Vitamin A | 7324 | 4000 | 6041 | 4000 | 8773 | 5000 | 11552 | 5000 | 7308 | 4000 | 15708 | 5000 |
| Vitamin $B_1$ | .9 | 1.1 | .8 | 1.1 | 2 | 1.2 | 1.6 | 1.3 | 1 | 1.2 | 2.2 | 1.5 |
| Vitamin $B_2$ | 1.1 | 1.3 | 1 | 1.3 | 2.6 | 1.5 | 2.1 | 1.5 | 1.4 | 1.5 | 3.7 | 1.8 |
| Vitamin $B_{12}$ | 3.1 | 2.4 | 3 | 7.4 | 3 | 6.5 | 3 | 4.2 | 3 | 6.8 | 3 | 3 |
| Vitamin C | 92 | 60 | 112 | 60 | 138 | 60 | 114 | 60 | 127 | 60 | 275 | 60 |
| Carbohydrate | 128 | 311 | 128 | 324 | 219 | 353 | 223 | 367 | 134 | 360 | 273 | 439 |
| Cholesterol | 194 | 300 | 98 | 300 | 436 | 300 | 366 | 300 | 185 | 300 | 682 | 300 |
| Unsat. Fat | 20 | 24 | 17 | 25 | 37 | 27 | 30 | 28 | 17 | 28 | 52 | 34 |
| Total Fat | 33 | 71 | 26 | 74 | 71 | 81 | 58 | 84 | 32 | 83 | 91 | 101 |
| Calcium | 490 | 800 | 463 | 800 | 1206 | 800 | 1039 | 800 | 915 | 800 | 1660 | 800 |
| Iron | 12 | 18 | 10 | 10 | 16 | 10 | 20 | 10 | 9 | 18 | 23 | 10 |
| Magnesium | 229 | 300 | 204 | 300 | 349 | 350 | 312 | 350 | 198 | 300 | 526 | 350 |
| Phosphorus | 802 | 800 | 751 | 800 | 1670 | 800 | 1279 | 800 | 1059 | 800 | 2350 | 800 |
| Potassium | 2717 | 3750 | 1973 | 3750 | 3436 | 3750 | 3164 | 3750 | 2228 | 3750 | 3876 | 3750 |

TABLE V

STANDARD DEVIATIONS OF NUTRIENT INTAKE[1]

| Nutrient | Subject's Intake | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | |
| | S.D. | Range | S.D. | Range | S.D. | Range | S.D. | Range |
| Calories | 9.33 | 53.60- 87.48 | 14.53 | 56.42-128.12 | 18.55 | 51.51-139.32 | 8.97 | 25.91- 54.50 |
| Protein | 22.28 | 85.72-166.79 | 33.96 | 80.74-251.85 | 293.71 | 101.72-1476.56 | 24.43 | 44.92-129.84 |
| Dietary Fiber | 13.92 | 33.17- 81.33 | 37.74 | 71.67-210.00 | 16.01 | 36.00-112.00 | 11.23 | 59.00- 99.00 |
| Vitamin A | 124.93 | 67.62-531.78 | 6.72 | 53.78- 79.80 | 72.58 | 45.53-369.25 | 47.66 | 62.03-258.15 |
| Vitamin $B_1$ | 17.99 | 83.60-149.00 | 58.14 | 163.08-376.15 | 20.42 | 68.09-145.45 | 20.16 | 55.40-146.00 |
| Vitamin $B_2$ | 26.75 | 83.60-149.00 | 54.39 | 169.38-372.50 | 35.47 | 114.62-250.00 | 16.13 | 79.23-146.92 |
| Vitamin $B_{12}$ | 65.72 | 11.10-255.00 | 111.02 | 237.67-693.33 | 90.91 | 67.33-450.00 | 107.69 | 9.30-426.67 |
| Vitamin C | 54.86 | 55.67-228.33 | 61.10 | 223.33-445.00 | 164.07 | 26.50-648.33 | 62.16 | 73.50-268.33 |
| Carbohydrate | 8.13 | 41.91- 75.37 | 9.81 | 43.73- 86.70 | 13.37 | 33.97- 93.27 | 6.56 | 26.60- 51.49 |
| Cholesterol | 9.96 | 22.73- 54.00 | 38.42 | 124.00-309.67 | 174.05 | 44.67-890.00 | 15.70 | 19.27- 67.00 |
| Unsat. Fat | 31.61 | 80.96-176.20 | 54.84 | 70.00-330.00 | 27.18 | 70.84-175.00 | 39.41 | 13.04-160.86 |
| Total Fat | 18.11 | 44.44- 95.24 | 27.96 | 47.78-183.33 | 23.98 | 47.22-152.78 | 18.97 | 10.00- 80.00 |
| Calcium | 23.26 | 39.25-110.88 | 11.21 | 134.38-180.75 | 41.19 | 84.50-227.75 | 8.55 | 27.63- 59.63 |
| Iron | 26.45 | 90.00-180.00 | 45.23 | 130.00-320.00 | 18.64 | 33.33-122.22 | 29.86 | 90.00-190.00 |
| Magnesium | 14.45 | 34.57- 90.57 | 43.58 | 103.43-264.29 | 19.09 | 49.33-127.00 | 16.35 | 43.00-108.33 |
| Phosphorus | 25.55 | 68.13-171.88 | 52.43 | 211.38-422.50 | 41.17 | 133.88-289.00 | 20.37 | 61.75-153.50 |
| Potassium | 12.37 | 49.20- 93.15 | 22.65 | 70.69-156.29 | 14.53 | 46.67-101.79 | 11.51 | 37.12- 78.21 |

[1] Intakes expressed in the percentage of the Recommended Dietary Allowance for each subject.
[2] S.D. - Standard Deviation

TABLE V

Continued

| Nutrient | Subject's Intake 5 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|
| | S.D. | Range | S.D. | Range | S.D. | Range | .D. | Range |
| Calories | 11.13 | 47.77- 91.35 | 21.99 | 33.78-107.46 | 14.19 | 26.07- 94.40 | 6.77 | 22.53- 49.93 |
| Protein | 15.61 | 104.85-169.11 | 33.21 | 44.75-156.27 | 17.95 | 53.13-121.25 | 14.10 | 39.26- 94.48 |
| Dietary Fiber | 46.34 | 32.77-205.67 | 18.81 | 11.60- 77.33 | 18.76 | 22.30-100.33 | 19.92 | 35.67-119.00 |
| Vitamin A | 912.33 | 308.80-3894.60 | 170.16 | 17.58-625.05 | 144.37 | 26.10-479.68 | 107.67 | 41.35-413.23 |
| Vitamin $B_1$ | 85.28 | 88.55-373.64 | 40.79 | 46.50-233.00 | 27.14 | 41.82-150.00 | 19.89 | 30.00-116.36 |
| Vitamin $B_2$ | 78.01 | 75.71-330.71 | 32.95 | 63.25-186.67 | 32.79 | 54.00-204.62 | 12.74 | 36.31- 96.15 |
| Vitamin $B_{12}$ | 140.70 | 71.33-596.67 | 94.61 | 0.67-331.67 | 40.16 | 28.73-205.67 | 32.67 | 26.63-160.67 |
| Vitamin C | 100.56 | 18.50-381.67 | 57.39 | 24.17-225.00 | 75.55 | 22.17-268.33 | 82.62 | 63.83-436.67 |
| Carbohydrate | 11.21 | 34.04- 72.95 | 8.85 | 24.01- 53.87 | 18.47 | 17.30-109.32 | 7.97 | 24.66- 54.94 |
| Cholesterol | 46.64 | 37.67-213.00 | 61.67 | 16.87-267.00 | 40.29 | 14.97-141.00 | 16.59 | 12.23- 75.67 |
| Unsat. Fat | 47.03 | 68.00-244.00 | 83.94 | 51.16-386.04 | 47.31 | 16.66-204.16 | 29.73 | 8.00-132.00 |
| Total Fat | 29.87 | 46.05-155.26 | 56.66 | 35.58-244.62 | 22.13 | 10.85- 84.51 | 12.65 | 5.27- 59.46 |
| Calcium | 27.05 | 32.88-162.25 | 38.81 | 23.25-186.00 | 28.03 | 37.38-142.25 | 15.80 | 22.13- 96.13 |
| Iron | 106.27 | 140.00-480.00 | 35.97 | 70.00-190.00 | 19.13 | 38.89-116.67 | 16.83 | 60.00-130.00 |
| Magnesium | 38.95 | 45.14-173.71 | 26.05 | 25.50-134.67 | 22.24 | 40.33-150.33 | 14.86 | 31.73-103.67 |
| Phosphorus | 43.28 | 112.38-264.50 | 32.49 | 55.13-180.25 | 30.25 | 56.25-185.38 | 19.38 | 51.00-125.25 |
| Potassium | 16.65 | 47.49-102.37 | 13.55 | 25.55- 84.91 | 79.91 | 29.28-409.79 | 12.64 | 33.39- 83.87 |

TABLE V

Continued

| Nutrient | Subject's Intake | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 9 | | 10 | | 11 | | 12 | |
| | S.D. | Range | S.D. | Range | S.D. | Range | S.D. | Range |
| Calories | 13.61 | 56.66-106.87 | 7.57 | 54.01- 80.13 | 7.90 | 29.61- 58.53 | 7.34 | 64.90- 87.66 |
| Protein | 23.25 | 98.50-191.78 | 18.04 | 80.39-147.37 | 14.75 | 57.33-107.86 | 14.03 | 93.40-139.10 |
| Dietary Fiber | 39.61 | 48.33-170.67 | 27.20 | 52.33-157.33 | 24.73 | 14.70-122.00 | 36.79 | 93.67-220.33 |
| Vitamin A | 136.08 | 46.68-538.80 | 139.71 | 72.08-525.20 | 119.60 | 31.13-557.88 | 84.31 | 156.46-468.18 |
| Vitamin $B_1$ | 47.40 | 94.17-263.33 | 26.47 | 93.08-186.15 | 20.34 | 50.00-135.00 | 26.44 | 130.00-214.67 |
| Vitamin $B_2$ | 44.68 | 124.67-285.33 | 21.13 | 86.87-197.33 | 17.75 | 65.13-138.00 | 23.22 | 164.44-240.00 |
| Vitamin $B_{12}$ | 84.34 | 116.00-416.67 | 62.05 | 125.67-360.00 | 44.25 | 53.33-233.33 | 76.09 | 109.67-350.00 |
| Vitamin C | 137.90 | 64.33-468.33 | 92.42 | 59.67-358.33 | 138.37 | 28.83-533.33 | 149.58 | 195.00-735.00 |
| Carbohydrate | 13.04 | 45.04- 87.54 | 8.96 | 44.96- 78.20 | 6.54 | 23.11- 46.67 | 6.51 | 48.52- 69.02 |
| Cholesterol | 40.83 | 61.00-197.33 | 34.27 | 27.43-163.33 | 62.47 | 13.17-206.67 | 19.34 | 201.00-257.00 |
| Unsat. Fat | 37.14 | 55.56-200.00 | 25.59 | 53.58-150.00 | 28.89 | 29.10-138.18 | 38.75 | 98.50-214.92 |
| Total Fat | 23.66 | 40.74-129.63 | 17.10 | 29.76- 97.62 | 17.69 | 16.87- 83.13 | 28.31 | 62.38-129.70 |
| Calcium | 24.77 | 116.25-208.25 | 36.52 | 72.63-221.25 | 29.56 | 51.50-150.25 | 36.05 | 162.75-263.63 |
| Iron | 64.62 | 90.00-300.00 | 33.98 | 130.00-260.00 | 14.90 | 22.22- 83.33 | 26.69 | 190.00-270.00 |
| Magnesium | 41.40 | 56.00-188.57 | 16.23 | 63.14-137.71 | 15.36 | 34.67- 89.00 | 21.78 | 107.14-172.29 |
| Phosphorus | 54.32 | 143.50-342.13 | 23.53 | 122.63-228.50 | 21.34 | 84.00-170.50 | 24.61 | 249.25-323.13 |
| Potassium | 19.40 | 68.00-141.44 | 15.94 | 59.39-116.96 | 13.24 | 28.35- 80.95 | 10.66 | 88.96-120.27 |

TABLE VII

STANDARD DEVIATIONS OF FASTING BLOOD GLUCOSE

| Subject | S.D. | Range | Subject | S.D. | Range |
|---|---|---|---|---|---|
| 1 | 9.07 | 153–187 | 7 | 24.93 | 86–177 |
| 2 | 69.02 | 63–284 | 8 | 5.74 | 99–113 |
| 3 | 53.88 | 51–266 | 9 | 53.27 | 68–251 |
| 4 | 13.49 | 184–213 | 10 | 56.77 | 102–300 |
| 5 | 27.83 | 29–117 | 11 | 84.81 | 28–291 |
| 6 | 13.57 | 124–175 | 12 | 17.84 | 66.125 |

# VITA

2

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