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Comparison of Weight Reduction of Human Subjects Fed 1300 Calorie, Lacto-Ovo-Vegetarian Diets with Two Levels of Carbohydrate

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COMPARISON OF WEIGHT REDUCTION OF HUMAN SUBJECTS FED 1300 CALORIE, LACTO-OVO-VEGETARIAN DIETS WITH TWO LEVELS OF CARBOHYDRATE

by

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Each person whose signature appears below certifies that he or she has read this thesis and that in his or her opinion it is adequate, in scope and quality, as a thesis for the degree of Master of Science.

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CHAPTER I

INTRODUCTION AND PURPOSE OF THE STUDY

The problem of obesity has plagued mankind ever since the very earliest times and today is recognized as a most dangerous health hazard. A great amount of scientific, monetary, and personal endeavor is expended each year to control and remedy this problem. Many theories of weight loss have been proposed in the pursuit of the "ideal" weight reduction program, one which insures optimal weight loss with minimal hunger.

I. REVIEW OF THE LITERATURE

History of weight reduction. As early as 1856 the thought occurred to William Harvey that excessive obesity might be similar to diabetes in its cause, although widely diverse in its development; and that if a purely animal diet was useful in the latter disease, "that a combination of animal food with such vegetable diet as contained neither sugar nor starch, might serve to arrest the undue formation of fat." He soon tested this theory by prescribing "a strict non-farinaceous and non-saccharine diet" containing approximately 24 ounces of meat with fat per day for an obese patient. The success of this regime set off a series of scientific debates and studies which alternately shifted between diets allowing protein and fat only and diets restricting total calories indiscriminately.[48]

In the early 1950's, Pennington published his theory concerning obesity and weight reduction. Since this time many other investigators have tried variations of this regime.[48]

Theory of the low carbohydrate diet. The theory of the low carbohydrate diet is in essence the Pennington theory, for most contemporary concepts in this area are attributable to him. The work of other investigators appears to be either supportive or examinative of his original theory.[23,50,66]

According to Pennington, obesity is in most cases "a compensatory hypertrophy of the adipose tissues, providing for a greater utilization of fat by an organism that suffers a defect in its ability to oxidize carbohydrate."[48] He described this defect in metabolism as a decreased ability to channel pyruvic acid through the oxidative cycle resulting in a build up of this substance which in turn increased the flow toward fatty acid synthesis and storage.[11] Pennington suggested that the defect may be caused by such factors as heredity, infection, pregnancy, surgical anesthesia, allergy or increasing age. An increased insulin secretion seemed to accompany this defect and thus enhanced fat storage.[50]

Pennington believed that the usual treatment, caloric restriction, had no scientific basis in an understanding of the pathophysiology of obesity, but was merely a "nonspecific form of therapy that reduced the weight by semi-starvation."[48]

To remedy this situation, Pennington suggested a carbohydrate intake low enough to insure complete oxidation of all pyruvic acid

formed, thus completely removing this source of fatty acid synthesis.[47] In actual practice he believed it most effective to eliminate carbohydrate from the diet completely and to allow an ad libitum intake of protein and fat.[48] This carbohydrate restriction also removed the stimulus from the insulin mechanism so that the fat storing activities of insulin were at a minimum. Thus the body was forced to mobilize its own adipose stores and oxidize these to ketones to supply its caloric needs. Pennington further stated that ketones were the preferred body fuel, however, other authorities disagreed with this interpretation of the literature.[50]

Weight loss on the low carbohydrate diet. Pennington has stated that an obese person adhering strictly to his diet, which he claimed contained approximately 2400 calories, could expect to lose seven pounds of weight per month.[50] There is some debate as to whether his patients actually consumed this level of calories.[50] Yudkin and Carey (1960) found that obese patients instructed to limit carbohydrate intake only and eat protein and fat as desired actually reduced their previous intake by 200 to 1900 calories per day.[77]

Cederquist (1952) studied weight loss of overweight (8 to 41 per cent) college girls on low-fat and low-carbohydrate diets. Weight loss of four subjects on the low-fat diet providing about 1200 calories over a period of sixteen weeks averaged 3.5 kilograms. Weight loss of seven subjects on a 1500 calorie, low-carbohydrate diet (carbohydrate 85 to 90 grams) for a similar period averaged 12.9 kilograms. Salt was slightly restricted on both diets.[9]

Taller (1962) reported weight losses ranging from 9.1 to 40.9 kilograms in a series of ninety-three obese women treated with his low carbohydrate regime for a period of at least one year. The Taller program was similar to the Pennington diet except that Taller allowed various small additions of carbohydrate containing foods, depending upon the ketotic state of the individual. Taller reported "marked reduction in body measurements, many times out of proportion to the weight loss."[66]

Kekwick and Pawan (1956) conducted studies with persons at least 35 per cent overweight in a hospital metabolic ward. After a stabilization period on an ad libitum diet, six patients were placed on a diet consisting of 20 per cent protein, 47 per cent carbohydrate, and 33 per cent fat ranging from 500 to 2000 calories for periods of seven to nine days each. Daily water intake was 3000 milliliters and NaCl was 10 grams. A definite relationship was observed between the caloric level and the weight loss. Fourteen patients were then placed on 1000 calorie diets in which 90 per cent of the calories were provided in turn by carbohydrate, fat, and protein. Water and NaCl were restricted as before. Weight loss was most rapid on the high-fat diet. Weight was maintained on the high-carbohydrate diet. There was no apparent malabsorption of fat or protein. Body water as per cent of body weight remained relatively constant throughout the study. The weight loss on the high-fat or high-protein diets was reported to be approximately 30 to 50 per cent water and 50 to 70 per cent adipose. One patient who maintained weight on a 2000 calorie diet of normal proportions was reported to have lost weight when changed to a 2600 calorie, high-fat, high-protein diet.[28]

Benoit and co-workers (1965) conducted studies in which seven Naval personnel were fasted for ten days, fed a 1000 calorie mixed diet for four days, and then fed either a 1000 calorie low-carbohydrate (10 grams) diet, or a mixed diet of normal distribution for another ten days. Weight loss was greatest during the fast, was intermediate on the ketogenic diet, and least on the mixed diet. The weight loss on the ketogenic diet was more constant and even than on the fasting period during which rapid initial loss soon decreased in rate.[6]

A number of other investigators have not found increased weight loss on low-carbohydrate diets. Pilkington and co-workers (1960) conducted a study in which obese patients isolated in a metabolic unit were given 1000 calorie diets for periods up to ninety-six days. The composition of the diets was alternated from predominantly carbohydrate to predominantly fat for periods of from eighteen to twenty-four days each. They observed a steady and consistent weight loss with each subject over the entire restricted period apart from minimal fluctuations involving water balance which occurred during the first ten days of adjustment to a new regime. When the diet changed from low carbohydrate to high carbohydrate, water was gained. When the reverse change occurred, water was lost.[52]

A similar study was conducted by Kinsell and co-workers (1964) in which four grossly obese subjects were observed over a period of sixty-five to seventy-seven days divided into dietary periods of twenty-one to twenty-eight days each. Diets tested were isocaloric with variations in protein, carbohydrate, and fat. Fat varied from 12 to 83 per cent,

protein from 14 to 30 per cent, and carbohydrate from 3 to 64 per cent. In all subjects the rate of weight loss was essentially constant throughout the entire study. The authors concluded that most studies of this type are not continued long enough. Slight variations which appear in any reducing program even out when carried over a long period of time.[31]

In studies conducted by Olesen and Quaade (1960), eight obese females were allowed ad libitum diets during a hospital adjustment period. After calculation of their exact caloric intake (average = 1950 calories), each was placed on an isocaloric, low-carbohydrate (<25 grams), high-fat diet. In all subjects weight loss occurred for five to seven days at which time they stabilized and maintained weight. All subjects were then placed on a 1250 calorie, high-carbohydrate diet (60 per cent). They continued to maintain weight, however, their basal metabolic rates showed that this calorie intake was less than their minimum energy requirements, and it was therefore assumed that they had drawn on their own energy stores. The authors concluded that the weight maintenance was due to water retention.[45]

In studies with rats, Samuels (1946) noted that when a high-carbohydrate diet was changed to an isocaloric, high-fat or high-protein diet, diarrhea occurred with considerable loss of unchanged food material. After several days, digestion and absorption were normal as before. This occurrence was thought to indicate a metabolic adjustment of the secretory cells in order to produce sufficient amounts of required digestive enzymes.[60]

Studies in which Galbraith and co-workers (1966) fed obese persons low-carbohydrate diets with estimated caloric deficits of from 2000 to 2600 calories per day yielded weight losses of 4.3 to 5.3 pounds per week. These losses closely corresponded to the calculated estimates of 4.7 to 6.1 pounds based on the generality that one pound of adipose yields 3000 calories. Subjects displayed the initial diuretic effect of a low-carbohydrate diet and thus lost more during the first week. The authors concluded that these results upheld the laws of the conservation of energy and did not support the theory that the obese individual has a unique metabolism. They suggested that many obese people fail to lose weight due to "additional unrevealed food intakes which they are most disinclined to admit."[15]

These authors further believed that many obese patients reduce their caloric intake and start to lose weight before going to a physician about a weight problem or starting on a weight loss study. The accuracy of metabolic studies in the obese may be completely dependent upon a base line period when they are receiving enough food to meet calorie requirements and are maintaining stable weight.[15]

Electrolyte, mineral and water balance on the low carbohydrate diet. Bloom (1962) found that sodium excretion in the urine of fasting patients was increased by intakes of fat, protein, or exogenous NaCl, but dropped immediately when 600 calories of carbohydrate was given. Regardless of negative caloric balance, weight loss decreased or completely ceased due to sodium and hence water retention. Exogenous

NaCl or 600 calories of fat or protein did not alter the weight loss of fasting.[7] Elsback and Schwartz (1961) noted marked, prolonged, positive sodium balances in obese patients during periods of weight reduction. Often these were sufficient to prevent weight loss on a 600 calorie diet. Similar delays in sodium excretion did not occur in non-obese patients or in obese patients on weight maintenance diets.[13] Gordon (1963) has observed similar occurrences to the extent of pitting edema.[19] Bansi and Olsen (1959) demonstrated that obese human subjects had a diminished glomerular filtration rate, elevated titer in blood of posterior pituitary antidiuretic hormone, and a markedly reduced renal clearance of water.[3]

Effects of the low carbohydrate diet on basal metabolic rate and energy metabolism. In studies which compared the metabolism of overweight, average weight, and underweight women, Hawthorne and co-workers (1956) observed a significantly higher mean basal energy rate for the overweight group (65.0 as compared to 52.2 and 47.0 calories per hour, respectively) as well as a higher caloric expenditure per hour after a test meal. The caloric increases were considerably greater for the underweight group, especially after a high-fat test meal.[23]

Gordon (1963) contradicted this report. He indicated that many or most overweight subjects manifest one or more abnormalities indicative of a hypometabolic state such as decreased thyroid activity, lowered Protein Bound Iodine (PBI) values, or delayed Achilles reflex.[19]

Several investigators have found a decreased CO_2 production on a high-fat diet, whereas glucose carbon incorporation into glyceride-glycerol was unaltered.[35,65]

Kekwick and Pawan (1964) conducted studies in which carbon loss of mice as CO_2 and in urine and feces was compared on normal and high-fat diets. They observed that animals lost half their carbon as CO_2 and half in the urine and feces on a diet of normal proportions as well as on a diet composed of 80 per cent fat. When the total calories of the high-fat diet were reduced by 50 per cent, CO_2 still accounted for half of the carbon, with the loss in urine much greater than in feces. When a high-carbohydrate diet was substituted, the excretion as CO_2 increased while the contribution of urine and feces together dropped.[29]

Increases of urinary carbon losses on high-fat diets consisted not only of acetone, but of increased amounts of citric acid, lactic acid, and pyruvic acid as well.[29] It has been suggested that perhaps the loss of these complex organic compounds with an energy value of their own offers some explanation for increased weight loss on high-fat, low-carbohydrate diets.[6,29] Studies in which Miller and Payne (1962) directly measured the energy value of urine and stools from pigs and rats and deducted this from their energy intake seemed to indicate that with even this correction, the animals' weights could be maintained constant with diets of widely different caloric values.[40] It was suggested that the ultimate explanation of varying rates of weight loss on diets of equal energy values may be more complex.[29]

Pennington stated that when carbohydrate alone was restricted, there was no decline in the basal metabolic rate.[47,49]

In weight reduction studies conducted by Taller (1962), increases in the PBI's from low normal to high normal were observed in ninety-

three female patients after six months on his low-carbohydrate, weight reduction program. (No thyroxine was given)[19] In a similar weight reduction study with obese college girls on a high-fat, low-carbohydrate, 1500 calorie diet for a period of sixteen weeks, Cederquist and co-workers (1952) observed a decrease in mean basal energy output. Out of seven subjects, the basal energy output remained relatively constant for two subjects, increased for one subject, and decreased 150 to 340 calories for four subjects. Daily energy expenditures indicated decreases of 45 to 340 calories for six subjects and an increase of 350 calories for one subject.[9]

Swift and co-workers (1959) compared the heat production of two matched pairs of normal human males on high fat and high carbohydrate diets by means of a respiration calorimeter. After twenty-four hour periods within the calorimeter, differences in total daily energy expenditure between the two diets were found to be insignificant. Subjects on the high fat diet gave off 3 per cent greater heat after ten days on the diet than after only three days. This was believed to suggest a slight metabolic adjustment.[65]

Nitrogen balance on the low-carbohydrate diet. Schwarz and co-workers (1966) have compared the reactions of obese and non-obese to a period of total starvation. They found that the percentile contribution of protein to total caloric expenditure appeared to be lower in the obese.[85] Kekwick and co-workers (1959) similarly found that obese subjects on a 1000 calorie, 90 per cent fat diet providing only 12 grams

carbohydrate remained near nitrogen equilibrium whereas lean subjects on the same diet were in negative balance.[30]

In studies conducted by Azar and Bloom (1963), it was observed that normal weight subjects on a 2000 calorie ketogenic diet (75 per cent fat, 25 per cent protein) for a four-day period remained in slightly positive nitrogen balance while consuming 150 grams of protein daily, but were in negative nitrogen balance after the second day when consuming only 100 grams of protein. Urinary nitrogen excretion increased in all subjects on this diet. These observations were believed to indicate that more protein was required to remain in nitrogen balance on a ketogenic diet.[2]

Ketone levels on the low-carbohydrate diet. There was agreement among investigators that high-fat, low-carbohydrate diets led to increased ketone body levels.[2,6,18,30,32,51] Benoit and co-workers (1965) reported an even greater rise in ketone values during a ketogenic diet than during a complete fast.[6] Several investigators have further noted that the obese appeared somewhat resistant to this change.[18,30] Gordon (1960) suggested that this is probably due to some enzymatic mechanism in the liver in obesity which may protect Krebs cycle intermediates from the breakdown that usually occurs in the absence of the constant regeneration normally derived from metabolism of carbohydrates.[18]

Serum insulin and glucose levels on the low-carbohydrate diet. The relationship between obesity and diabetes mellitus has long been established. Numerous investigators have observed impaired glucose

tolerance in both obese human subjects and in animals.[1,33,57,76] Yalow and co-workers (1965) have observed that weight reduction to normal or near normal levels was frequently followed by at least temporary remission of overt diabetes and even by the attainment of normal glucose tolerance. They added that obesity is not necessarily a pre-diabetic state.[76]

Arendt and Pattee (1956) have speculated that continuous mechanical stress accompanying obesity, could, over a period of years, lead to increased production of endogenous adrenocortical hormones, not necessarily measurable by present methods. This might induce gradual changes in metabolism such as impairment of glucose tolerance.[1]

Cahill and co-workers (1966) reported that after a fast, the glucose tolerance of normal subjects was grossly abnormal, whereas diabetic subjects showed no change in tolerance and were generally indistinguishable from the normals at this time.[8] Yalow and co-workers (1965) observed a similar occurrence when obese were compared with normal subjects after two and a half to nine days of fasting. The obese, whether diabetic or non-diabetic, showed no increased impairment of glucose tolerance or changes in plasma insulin response.[76]

Morse and Mahabir (1964) have observed that glucose tolerance curves were lower in obese than in normal subjects after a twenty-three hour fast. During the same study, the obese were observed to be less sensitive to insulin. It was concluded that the obese must have secreted far greater amounts of insulin than the normal subjects.[41]

In studies with overweight, average weight, and underweight women, Hawthorne and co-workers (1956) found a highly significant,

positive relationship between the fasting glucose concentrations and the percentage deviations from desirable weight.[23] In studies with sixty-five obese subjects (all females except two), aged 23 to 65 years and 14 to 137 per cent overweight, Ogilvie found that glucose tolerance diminished as the duration of obesity increased. Tolerance appeared to be unimpaired until obesity existed for more than eleven years. Thereafter tolerance decreased.[44]

Morse and co-workers (1960) observed that females with long-standing obesity but no family or personal history of diabetes exhibited impaired glucose tolerance in response to an oral glucose load but had normal net glucose removal rates and a normal rise in blood pyruvate in response to an intravenous test load.[42]

Karem and co-workers (1965) have observed an excessive serum insulin response in the obese. They believed that this response, which is so typical of maturity onset diabetes, may actually have been a characteristic of obesity itself rather than the diabetic state.[27] Hereditarily obese hyperglycemic mice, which appear physiologically similar to obese humans, have also shown higher levels of pancreatic insulin and circulating insulin-like activity than non-obese controls.[11,75]

It seems to follow that the obese have decreased sensitivity to available insulin. Randle and co-workers (1963) have attributed this to one or the other of two possible causes: (1) "Diminished responsiveness of the membrane-transport system to the action of insulin, or (2) inhibition of glucose phosphorylation."[55] Other

investigators have attributed impaired glucose tolerance to elevated free fatty acid (FFA) levels.[4,22,55,61,69] However, Samols and co-workers (1964) found no correlation between FFA levels and response to oral glucose.[59] Recant and Haluk (1965) also found no correlation between FFA levels and insulin antagonism. They found inhibiting fractions associated with albumin. This inhibitor was found to have at least one hundred times greater inhibitory activity in muscle than intact albumin alone. In adipose tissue the inhibitor seemed to display an insulin-like activity and appeared to exaggerate the effect of added crystalline insulin on glucose utilization by the tissue.[56]

Vallence-Owen (1965) believed that this synalbumin antagonism was related to the pituitary because albumin from hypophysectomized subjects was devoid of insulin antagonism.[68] Lowy and co-workers (1961) have indicated that there is no such relationship.[37] Ensinck and Vallence-Owen (1963) suggested that the beta-chain of insulin may be the synalbumin antagonist and that antagonism of insulin may occur at the cell membrane by direct competition for insulin binding sites by a part of the insulin molecule.[14]

Growth hormone and the low-carbohydrate diet. Jansz and co-workers (1963) reported that in health the fasting growth hormone level was consistently higher than the level after a meal. They found a high-carbohydrate meal to have the greatest lowering effect.[26] Other investigators have also reported this inverse relationship between growth hormone and glucose levels.[17,24] Roth and co-workers (1963) found

growth hormone secretion to be stimulated in normal subjects by hypoglycemia as well as by a rapid fall in blood glucose without hypoglycemia, muscular exercise, and prolonged fasting. In the obese only hypoglycemia stimulated secretion.[58]

A number of investigators have found the obese to have significantly lower or undetectable levels of growth hormone during fasting as compared to normal controls.[4,58,62] Yalow and co-workers (1965) also found the obese to have a less marked growth hormone rise during the fourth and fifth hours following glucose administration than did normal subjects.[76] Ikkos and co-workers (1957) found that 30 milligrams of human growth hormone given for three days to eleven normal patients decreased glucose tolerance in eight.[25] Stein and co-workers (1962) observed similar results and hypothesized that "human growth hormone impairs the physiologic effectiveness of endogenous insulin by depressing the insulin responsiveness of the peripheral tissues and/or stimulating the elaboration of plasma insulin inhibitors."[64]

Administration of growth hormone was reported to increase ketone body formation in hypophysectomized diabetic subjects as well as in normal fasting rats.[5,64]

Raben and Hollenburg (1959) reported that small doses of human growth hormone elevated plasma fatty acids which to them suggested a role in fat mobilization.[54]

Serum lipids on the low-carbohydrate diet. Waxler and Craig (1964) have observed that latent diabetic obese women have higher

triglyceride and total serum lipid values than non-diabetic obese women which in turn have elevated levels as compared to normal women. In the normal weight group serum lipid levels seemed to increase with advancing age.[72] Walker and co-workers (1963) found a direct correlation between caloric balance and serum lipoproteins regardless of the lipid intake. The degree and permanency of the lipoprotein reduction was thought related to the initial level of Sf 12-20 lipoproteins and not to the initial degree of obesity. The influence of weight loss in reducing serum lipids was greater and more consistent in subjects with initial lipoprotein levels of 50 milligram per cent or more. In subjects below this level no reduction or a reduction followed by a rebound were found.[70]

MacDonald and Barry (1964) observed an inverse relationship between weight changes and the linoleic acid content of adipose tissue in men on a moderately low carbohydrate reducing diet. No such changes were seen in the fatty acid distribution of women.[39] In hypothalamic obese rats a similar inverse relationship was noted between degree of obesity and the linoleic to palmitic ratio.[20] MacDonald (1962) has shown in studies with adult rabbits that an increase in carbohydrate intake resulted in a decrease in the linoleic to myristic and palmitoleic ratio in liver and adipose tissue.[38]

In studies with overweight, average weight, and underweight women, Hawthorne and co-workers (1956) observed no significant differences among fasting serum lipid values of these three groups. After a high-fat test meal, total lipid values increased slightly in all groups.

After a high-carbohydrate test meal the total lipids for only the overweight group increased; the average group showed no net change, while the underweight group decreased somewhat.[23]

Several investigators have observed that obese persons subjected to a prolonged fast respond with an early rise in FFA but level off to a relatively flat curve as the fast continues.[4,18,41,46,62] Constitutionally thin, hyperkinetic subjects showed much steeper rises in blood FFA values while fasting.[18] This would lead to the conclusion of inadequate FFA mobilization in the obese and hence decreased lipolysis during fasting.[46]

Yalow and co-workers (1965) have observed a normal lowering of FFA after glucose administration in non-ketotic diabetics and in the obese. This indicated to them normal or near normal sensitivity of adipose tissue to endogenous insulin in contrast to diminished insulin sensitivity of glucose metabolism.[76]

Hales and Randle (1963) have observed increased fasting FFA concentrations in normal subjects after a low-carbohydrate diet, in spite of a rise in plasma concentrations of insulin and glucose to levels which, with a high-carbohydrate diet, would have lowered the plasma FFA concentration.[22] Chalmers and co-workers (1958) reported that a fast or a low-carbohydrate diet resulted in the presence of a substance in the urine of healthy persons which seemed to mobilize depot fat when injected into experimental animals.[10] Taller (1962) reported that a low-carbohydrate diet lowered the serum triglyceride level which he used in turn as an index of lipogenesis.[66]

Others reported that the low-carbohydrate diet resulted in increases in blood lipids, especially cholesterol.[32,36] Increased intake of saturated fat usually associated with this diet was felt to be the cause.[36] Gordon (1963) reported that a low-carbohydrate diet high in polyunsaturated fat increased the oxidation of body fat.[19]

Galbraith and co-workers (1966) found that weight loss was accompanied by a decrease in cholesterol levels irrespective of large amounts of cholesterol in the diet. They felt that dietary cholesterol did not affect serum lipids of persons in negative caloric balance.[15]

Satiety value of the low-carbohydrate diet. In a study conducted by Cederquist and co-workers (1952), obese college girls on a 1500 calorie, low-carbohydrate diet reported a feeling of wellbeing and satisfaction with very little hunger between meals. Subjects on an isocaloric diet with higher carbohydrate intake became discouraged because of continuous hunger.[9] Taller (1962) observed similar favorable reactions to a low-carbohydrate diet with obese women.[66] Persson and co-workers (1967) in studies with adolescent boys reported extreme hunger, fatigue and nausea during the fasting state after four days on a low-carbohydrate, 3700 calorie diet.[51]

II. PURPOSE OF THIS STUDY

The present investigation was undertaken (1) to compare weight reduction of human subjects fed 1300 calorie, highly polyunsaturated fat, lacto-ovo-vegetarian diets with two carbohydrate levels, 30 per

cent and 50 per cent of the total calories; (2) to compare glucose tolerance curves, serum insulin, free fatty acid, uric acid, and cholesterol levels on these two diets; and (3) to compare the satiety value of these two levels of carbohydrate.

CHAPTER II

METHODS OF EXPERIMENTATION

Two groups of twelve overweight subjects each (nine women; three men) consumed a 1300 calorie, highly polyunsaturated fat, lacto-ovo-vegetarian diet for a period of five weeks. One group was fed a 30 per cent carbohydrate level, and the other was fed a 50 per cent carbohydrate level which approximates the normal distribution.

I. SUBJECT SELECTION

Subjects accepted for this study were individuals at least 25 per cent overweight, with the exception of one who was only 8 per cent overweight.* Ages ranged from 23 to 61 years. Individuals were further evaluated for their willingness to eat the type of food provided on the study and their seeming reliability.

Interested persons were sent application blanks (Figure 9, page 73). From these blanks prospective subjects were selected and interviewed. During this time, the purpose and basic methods of the project were explained in greater detail with special emphasis on the important role of the subject. After completion of all interviews, final subject selection was made. Subjects for the 50 per cent carbohydrate group were chosen to correspond as closely as possible to the

*Normal weights were obtained from the Tables of Desirable Weights, Metropolitan Life Insurance Company, Statistical Bureau. For both men and women the upper figure for "medium frame" corresponding to given height was used.

30 per cent carbohydrate group in age, height, and per cent overweight (Tables I and II). The average age of subjects was 43 years in the 30 per cent carbohydrate group and 44 years in the 50 per cent carbohydrate group. The average per cent overweight of subjects was 47 per cent in the 30 per cent carbohydrate group and 51 per cent in the 50 per cent carbohydrate group.

II. DIETS

The 30 per cent carbohydrate and 50 per cent carbohydrate diets (Tables I to VIII) each consisted of four calculated daily menus which were repeated consecutively throughout each study period. The daily menus for each group were divided into three meals which were similar in distribution of calories, carbohydrate, protein, and fat.

The calorie distribution of the 30 per cent carbohydrate diet included 25 per cent protein, and 45 per cent fat. When converted to grams this yielded the following: 98 grams carbohydrate, 80 grams protein, and 65 grams fat. The moderately high protein content of this diet necessitated the use of daily allotments of cottage cheese and non-fat milk as well as other high protein foods produced by Loma Linda Food Company, La Sierra, California, at each meal. Each subject also received one egg daily, this being the only source of animal fat. The remaining fat calories were supplied by corn oil used for frying or corn oil margarine. The 30 per cent carbohydrate diet had a P/S ratio of 2.1. Due to the restriction in carbohydrate, only two servings of artificially sweetened fruit were allowed per day, and bread was usually limited to

TABLE I

HEIGHT, INITIAL WEIGHT AND AGE OF SUBJECTS:
THIRTY PER CENT CARBOHYDRATE GROUP

Subject	Height		Initial Weight	Desirable Weight	% Overweight	Age
	ft	in	lbs	lbs		yrs
Women:						
BB	5	½	182.5	121	51%	40
AC	5	4	252.0	134	88%	54
FD	5	3	181.0	130	39%	36
IHa	5	5	207.0	139	49%	58
IHe	5	1	204.8	122	67%	40
HN	5	3	140.2	130	8%	54
MP	4	11	210.0	116	81%	60
VS	5	1	184.5	122	51%	27
GT	5	1	154.0	122	26%	28
Men:						
LS	5	8	208.0	157	32%	23
WS	5	9½	226.5	163	39%	41
CW	5	7	204.0	152	34%	53

TABLE II

HEIGHT, INITIAL WEIGHT AND AGE OF SUBJECTS:
FIFTY PER CENT CARBOHYDRATE GROUP

Subject	Height		Initial Weight	Desirable Weight	% Overweight	Age
	ft	in	lbs	lbs		yrs
Women:						
GB	5	1	168.2	122	38%	55
CD	5	1	218.0	122	75%	38
HF	5	0	158.2	119	33%	46
EH	5	½	194.2	120	62%	52
JL	5	6	230.0	143	61%	47
SM	5	2	181.0	126	44%	39
WM	5	3½	173.5	133	35%	34
EN	5	2	236.0	127	86%	61
JS	5	5	266.0	140	90%	31
Men:						
RB	5	7½	221.0	154	44%	36
KM	5	9	209.0	161	29%	47
RS	5	11	264.0	169	56%	44

one half slice per meal which at times was substituted by a small serving of potato. Only low calorie vegetables were used. In general, common foods were selected and prepared in a manner which would appeal to most persons. Low calorie products such as D-zerta, artificially sweetened jams and jellies, zero or low calorie salad dressings, low calorie catsup and various seasonings were used at times for interest and variety.

The 50 per cent carbohydrate diet, which included 20 per cent protein, and 30 per cent fat yielded a dietary distribution of 162 grams carbohydrate, 65 grams protein, and 43 grams fat. The food items used in this diet were similar to those used for the 30 per cent carbohydrate diet with the exception that larger amounts of high-carbohydrate foods and smaller amounts of high protein and fat items were included. Since a whole egg was also included each day on this diet even though the total fat intake was somewhat reduced, the P/S ratio was 1.8, a value slightly lower than on the 30 per cent carbohydrate diet.

Although the menus were calculated to provide recommended amounts of all vitamins and minerals as far as possible (Tables XI to XVIII, pages 65-72), each subject was daily given a multivitamin capsule (Natalins) to compensate for any possible inadequacy due to a continuously low caloric intake. The composition of each capsule was as follows: 40 milligrams iron, 250 milligrams calcium, 100 milligrams ascorbic acid, 600 USP units vitamin A, 400 USP units vitamin D, 1.5 milligrams thiamine, 2.5 milligrams riboflavin, 15 milligrams niacinamide, 3 milligrams pyridoxine, 5 milligrams calcium pantothenate, 2 micrograms cyanocobalamin.

Subjects were allowed water and salt ad libitum and a maximum of two cans of low calorie soft drink per day.

III. SERVICE PROCEDURE

Servings of high calorie foods were weighed on a Mettler balance. Low calorie items as salad greens, broth, and low calorie vegetables were weighed initially and then standardized servings given. At meal times subjects were served from the test kitchen in modified buffet style. While hot items were being served onto plates, subjects picked up their own pre-portioned cold items and placed these onto their trays. They then gathered around a large conference table in an adjoining room to eat. Disposable paper service was used. This meal time routine continued throughout the five-week period with the exception that every Saturday and Sunday noon each subject was given a sack lunch for the evening meal. An occasional sack lunch was also prepared by special request. These lunches contained the food items listed on the menu for that particular meal.

IV. TESTS EMPLOYED

Series of venous blood samples (fasting; half hour, one hour, two hours, and three hours after 100 grams of glucose administered orally) were drawn from each subject by the Loma Linda Medical Center clinical laboratory prior to each study and during its concluding week. During the third experimental week, fasting blood samples were drawn. Using standard methods, the clinical laboratory determined glucose tolerance

curves and analyzed for cholesterol and uric acid levels in each of the three fasting samples per study.

The Biochemistry Department of the School of Medicine, Loma Linda University, analyzed for free fatty acids using the titrametric method of Trout, et. al.,[67] and for serum insulin using the radioimmuno assay of Hales and Randle.[21]

At the end of the fourth week, urine samples were collected and analyzed for presence of ketone bodies using Ketostix.

V. DATA COLLECTION AND ANALYSES

Weight loss. Before breakfast each subject weighed and recorded his weight in a continuous manner on a sheet provided. From this data a weight loss graph was prepared for each subject. Weight loss means were determined for each group and differences in these compared for statistical significance by means of Student's t test.

Laboratory tests. Beginning and ending glucose tolerance curves in reference to beginning and ending serum insulin levels were compared in each subject. General trends were compared between groups.

Beginning and ending cholesterol, free fatty acid, and uric acid levels were compared for each subject as well as between subjects and groups. Statistical significance of change was determined by Student's t test.

Presence of ketone bodies was compared between groups.

Subject reactions and comments. Brief daily logs containing subjects' personal comments concerning physical and mental feelings were kept for the duration of the study. These were scrutinized for major trends and comparisons were made between groups.

At the conclusion of each study, a coded questionnaire (Figure 10, page 74) was given each subject to indicate, if possible, the degree of cooperation each had rendered and hence the validity of the data obtained.

CHAPTER III

RESULTS AND DISCUSSION

Weight loss. Weight loss occurred in all subjects on both diets and is recorded in Tables III and IV.

In the 30 per cent carbohydrate group, the average weight loss per week for women ranged from 1.3 to 3.3 pounds with a mean of 2.2 pounds. The average weekly loss for men ranged from 3.4 to 4.1 pounds with a mean of 3.8 pounds. The mean weekly weight loss for both men and women combined was 2.6 pounds. With both men and women, average weekly weight loss decreased slightly with each subsequent week except for the final week during which weight loss increased somewhat.

Total weight loss for the five week period for women in the 30 per cent carbohydrate group ranged from 6.5 to 16.5 pounds with a mean total loss of 10.9 pounds. Total weight loss for men ranged from 17.0 to 20.5 pounds with a mean total loss of 19.1 pounds. The mean total loss for men and women combined was 12.9 pounds. Since two subjects began the diet half way through the first week to replace two subjects who dropped out at that time, the average weight loss for week one as well as the total weight loss might have been slightly lower if these subjects had started with the others.

In the 50 per cent carbohydrate group, the average weight loss per week for women ranged from 2.0 to 3.1 pounds with a mean of 2.5 pounds. The average weekly loss for men ranged from 2.6 to 4.6 pounds with a mean of 3.4 pounds. The mean weekly weight loss for both men

TABLE III

WEIGHT LOSS OF SUBJECTS IN THE THIRTY PER CENT CARBOHYDRATE GROUP

Subject	Week 1	Week 2	Week 3	Week 4	Week 5	Mean Loss Per Week	S.E. of Mean	Total Weight Loss
	lbs	lbs	lbs	lbs	lbs	lbs		lbs
Women:								
BB	.5*	3.5	2.5	2.0	2.3	2.2	.49	10.8
AC	6.0	3.0	1.5	2.5	2.0	3.0	.79	15.0
FD	5.3	1.0	2.0	.7	1.0	2.0	.85	10.0
IHa	2.0	2.0	2.0	1.0	.0	1.4	.40	7.0
IHe	5.2	1.8	3.5	1.2	2.3	2.8	.71	14.0
HN	.5	2.0	1.0	2.2	1.0	1.3	.32	6.7
MP	4.0	2.0	1.0	3.0	1.5	2.3	.54	11.5
VS	4.5	3.5	2.0	2.0	5.0	3.3	.62	16.5
GT	2.5	1.5	1.5	1.0	.0	1.3	.41	6.5
Mean Values	3.4	2.2	1.9	1.7	1.7	2.2		10.9
S.E. of Mean	.69	.27	.26	.26	.51	.25		1.24
Men:								
LS	6.0	4.8	2.5	4.7	2.5	4.1	.69	20.5
WS	5.5	4.0	4.5	3.5	2.3	4.0	.53	19.8
CW	1.0*	6.5	2.3	2.2	5.0	3.4	1.01	17.0
Mean Values	4.2	5.1	3.1	3.5	3.3	3.8		19.1
S.E. of Mean	1.59	.69	.70	.72	.87	.21		1.07
Total Means	3.6	2.9	2.2	2.2	2.1	2.6		12.9
S.E. of Mean	.62	.46	.29	.34	.49	.29		1.43

* Began study half-way through first week

TABLE IV

WEIGHT LOSS OF SUBJECTS IN THE FIFTY PER CENT CARBOHYDRATE GROUP

Subject	Week 1	Week 2	Week 3	Week 4	Week 5	Mean Loss Per Week	S.E. of Mean	Total Weight Loss
	lbs	lbs	lbs	lbs	lbs	lbs		lbs
Women:								
GB	4.0	1.2	.8	.2	3.8	2.0	.79	10.0
CD	3.0	2.3	2.2	2.3	2.7	2.5	.15	12.5
HF	3.2	.5	2.3	2.2	2.0	2.0	.44	10.2
EH	6.0	.0	4.7	.0	2.0	2.5	1.22	12.7
JL	1.5	5.0	3.0	4.0	1.8	3.1	.66	15.3
SM	2.5	1.5	2.3	2.7	2.5	2.3	.21	11.5
WM	4.8	.2	1.5	2.0	3.8	2.5	.82	12.3
EN	5.5	1.5	.8	3.2	2.0	2.6	.82	13.0
JS	4.3	.7	4.0	3.0	2.8	3.0	.63	14.8
Mean Values	3.9	1.4	2.4	2.2	2.6	2.5		12.5
S.E. of Mean	.49	.51	.44	.44	.25	.12		.60
Men:								
RB	5.0	3.0	1.8	.2	3.0	2.6	.79	13.0
KM	5.0	3.8	3.5	2.2	8.3	4.6	1.04	22.8
RS	4.0	3.0	2.0	3.0	3.0	3.0	.32	15.0
Mean Values	4.7	3.3	2.4	1.8	4.8	3.4		16.9
S.E. of Mean	.33	.27	.54	.83	1.77	.60		2.99
Total Means	4.1	1.9	2.4	2.1	3.1	2.7		13.6
S.E. of Mean	.38	.45	.35	.37	.51	.19		.97

and women was again greatest during the first week of the study. Average weekly loss for women was least during the second week and then fluctuated somewhere between these two values during subsequent weeks with a slight increase during the last week. For men average weekly loss decreased slightly with each succeeding week up to the final week when a substantial increase in loss occurred.

Total weight loss for the five week period for women in the 50 per cent carbohydrate group ranged from 10.0 to 15.3 pounds with a mean total loss of 12.5 pounds. Total weight loss for men ranged from 13.0 to 22.8 pounds with a mean total loss of 16.9 pounds. The mean total loss for men and women combined was 13.6 pounds.

Differences in total weight losses between the 30 per cent carbohydrate and 50 per cent carbohydrate groups were found insignificant by analysis of covariance as well as by Student's *t* test. Allowances for the two subjects starting late in the 30 per cent carbohydrate group would bring these values even closer together or cause the loss of the 30 per cent carbohydrate group to slightly exceed that of the 50 per cent carbohydrate group. The average total weight loss for the women in the 50 per cent carbohydrate group was slightly greater than that for the women in the 30 per cent carbohydrate group. The average total weight loss for men, however, was greater in the 30 per cent carbohydrate group than in the 50 per cent carbohydrate group. Here again differences were not found significant.

Weight loss corresponded favorably with results of other reducing studies carried out for similar periods of time. Olesen and Quaade[45]

maintained one patient on a 1000 calorie diet for forty-five days. For the first twenty-four days the diet was composed of 50 per cent carbohydrate, 32 per cent protein, and 18 per cent fat; during the remaining twenty-one days the diet was composed of 18 per cent carbohydrate, 32 per cent protein and 50 per cent fat. Weight loss was identical for both periods and averaged approximately three pounds per week which is close to the values found in this study considering the difference in total caloric intake.

Pilkington and co-workers[52] observed weight loss in nine grossly obese subjects aged 28 to 59. Four subjects, maintained on an 800 calorie diet for periods of from six to twelve weeks with the percentage of carbohydrate alternating from 23 to 78 per cent of total calories, displayed steady weight loss throughout irregardless of carbohydrate level. Average weight loss per week was approximately three pounds. Five other subjects maintained on a 1000 calorie regime for from ten to fourteen weeks with carbohydrate composition varying from 9 to 91 per cent likewise lost at a consistent rate of approximately three pounds per week.

Kinsell and co-workers[31] reported that two female patients fed 800 to 850 calorie diets over a period of ten weeks with carbohydrate composition varying from 27 to 64 per cent lost consistently during the entire period at a rate of approximately 1.4 pounds per week. Two subjects, one male and one female, fed 1200 calorie diets over a similar period of time with carbohydrate ranging from 3 to 62 per cent also displayed even weight loss. The female lost at an average rate of 2.8

pounds per week while the male lost an average of 5.0 pounds per week. All four subjects were approximately fifty per cent overweight.

The results of these investigators along with the results of this study seem to uphold the hypothesis that long range weight loss is dependent upon caloric deficit irrespective of the relative composition of the diet.

The rapid initial weight loss observed in this study might be due to a decrease in intestinal content or to a change in fluid balance. Some investigators have reported the low carbohydrate diet to have an initial diuretic effect.[45,52] In this study this rapid initial loss appeared in both groups. Pilkington and co-workers[52] have noted similarly rapid losses at the commencement of reducing studies whether the diet was high or low in carbohydrate. However, they did observe temporary increases in weight when the diet was changed from low carbohydrate to high carbohydrate during the course of the study. Another possible explanation for this rapid initial weight loss is that the basal metabolic rate decreases in response to a caloric deficit as reported by Cederquist and co-workers.[9] A fourth possibility is that the subjects became more lax as time passed and indulged in snacking to a greater extent. The fact that weight loss again increased during the last week of each study would seem to uphold this. The subjects were once more extending maximal cooperation to lose weight in anticipation of the final weighing-in date.

In general, the subjects on this study seemed very cooperative

and reliable. One or two subjects in each group were suspected of snacking, although the extent was not known.

Two subjects (MP and GD) who lost 11.5 and 12.0 pounds, respectively, on the 30 per cent carbohydrate diet, were accepted again on the 50 per cent carbohydrate diet as "extras" to compare their response to the two programs. On the higher carbohydrate diet these subjects lost only 4.0 and 3.0 pounds, respectively. Unfortunately, the validity of this data must be questioned. In previous studies conducted by this department, a greater degree of carelessness has been noted in some subjects the second time they are on a study. Although subjects MP and GD did not admit eating additional food, from observations made it was strongly believed that these subjects were supplementing the diet provided. If this assumption is true, it may further be hypothesized that increased hunger associated with a higher carbohydrate diet (lower protein and fat) may have driven these subjects to between-meal snacking. Whether these two subjects failed to lose as much weight on a higher carbohydrate level because of metabolic reasons or because of increased hunger and consequent reduced ability to remain with the diet, the result was the same--decreased weight loss. So in the case of these two individuals, it can be said that the low carbohydrate diet was more effective.

Glucose tolerance and serum insulin. Although no subject with a known history of diabetes was accepted on this study, several subjects in each group exhibited abnormal responses to a 100 gram oral dose of glucose.

In the 30 per cent carbohydrate group, subjects AC and MP showed impaired glucose tolerance before the five week period. (Reference glucose tolerance curve: White, Handler and Smith[73]) Subject BB exhibited a slightly abnormal response, subjects FD, IHa, IHe, LS, and CW showed normal responses, while subjects HN, VS, and GT exhibited rather flat curves (Table V). Serum insulin determinations carried out at this time revealed that subjects MP and LS had excessive available insulin (Table VII).

During the final week of the five week period, glucose tolerance tests and serum insulin determinations were repeated. Results at this time indicated a marked reversion toward normal of previously abnormal glucose tolerance curves in subjects BB, AC, and MP as well as more normal peaks in the three subjects previously exhibiting flat curves.

In one case in the 30 per cent carbohydrate group, subject MP, an impaired glucose tolerance curve was accompanied by an extremely high serum insulin level before the study. This would imply the presence of large amounts of insulin which were for some reason ineffective. Another subject, GD, who was in a second study run concurrently with regular daily exercise,[16] exhibited similarly abnormal glucose tolerance accompanied by high serum insulin levels. At the conclusion of the five week period, these two subjects showed normal glucose tolerance along with greatly reduced serum insulin levels (Figures 1, 3, 5, and 7). It would appear that available insulin was more effective at this time. Because of this phenomenon, these two subjects were carried as extra subjects along with the twelve subjects in the 50 per cent carbohydrate

TABLE V

EFFECT OF A THIRTY PER CENT CARBOHYDRATE,
1300 CALORIE DIET ON GLUCOSE TOLERANCE

Subject		F	½	1	2	3	Hour
				mg/100 ml			
BB	A	81	187	134	108	69	
	B	88	151	115	84	72	
AC	A	91	149	164	160	159	
	B	67	124	139	93	101	
FD	A	76	119	107	89	45	
	B	57	113	89	85	68	
IHa	A	66	101	84	81	76	
	B	57	119	142	90	98	
IHe	A	83	143	107	91	46	
	B	67	113	140	91	76	
HN	A	73	79	82	69	40	
	B	72	116	85	48	38	
MP	A	97	172	185	126	103	
	B	76	115	134	72	81	
VS	A	73	87	58	81	90	
	B	55	99	87	88	77	
LS	A	91	154	103	72	64	
	B	72	114	120	66	56	
WS	A	82	168	142	95	52	
	B	73	123	136	77	37	
GT	A	60	83	50	63	67	
	B	60	180	72	67	53	
CW	A	86	153	186	114	59	
	B	58	125	166	76	34	
Means	A	80	133	117	96	72	
	B	67	118	119	78	66	

A = Initial glucose tolerance test, week prior to study
B = Ending glucose tolerance test, last week of study

TABLE VI

EFFECT OF A FIFTY PER CENT CARBOHYDRATE,
1300 CALORIE DIET ON GLUCOSE TOLERANCE

Subject		F	½	1	2	3	Hour
				mg/100 ml			
GB	A	92	144	103	65	43	
	B	75	89	81	81	78	
RB	A	78	135	101	78	51	
	B	69	103	109	78	76	
CD	A	113	196	200	172	69	
	B	79	158	161	158	111	
HF	A	74	144	157	139	92	
	B	72	119	98	110	77	
EH	A	77	156	182	111	81	
	B	86	144	170	113	64	
JL	A	82	128	137	125	80	
	B	72	119	93	84	67	
SM	A	86	154	161	113	101	
	B	82	155	175	134	80	
KM	A	81	131	112	110	89	
	B	76	133	90	73	70	
WM	A	75	57	72	52	41	
	B	69	103	92	72	65	
EN	A	139	254	322	332	268	
	B	94	180	252	254	147	
RS	A	95	110	145	60	90	
	B	89	124	172	115	72	
JS	A	72	123	162	111	89	
	B	65	118	144	107	79	
Means	A	89	144	154	122	91	
	B	77	129	136	115	82	

A = Initial glucose tolerance test, week prior to study
B = Ending glucose tolerance test, last week of study

TABLE VII

EFFECT OF A THIRTY PER CENT CARBOHYDRATE,
1300 CALORIE DIET ON SERUM INSULIN LEVELS

Subject		F	½	1	2	3	Hour
				mu/ml			
BB	A	--	---	---	---	---	
	B	21	96	110	37	23	
AC	A	12	30	40	80	73	
	B	19	19	66	66	42	
FD	A	12	47	63	21	2	
	B	16	89	61	68	35	
IHa	A	14	42	30	26	23	
	B	21	94	120	98	77	
IHe	A	16	80	80	51	9	
	B	16	66	84	63	42	
HN	A	16	---	130	40	19	
	B	14	320	---	59	23	
MP	A	21	63	160	400	160	
	B	16	40	49	---	56	
VS	A	16	150	84	96	100	
	B	9	100	82	84	77	
LS	A	37	250	210	77	12	
	B	21	73	110	44	33	
WS	A	14	110	120	73	19	
	B	--	59	100	37	16	
GT	A	14	110	51	56	49	
	B	16	98	98	---	40	
CW	A	9	44	84	75	16	
	B	16	51	51	47	14	
Means	A	16	93	96	90	44	
	B	17	92	85	60	40	

A = Initial serum insulin values, week prior to study
B = Ending serum insulin values, last week of study

TABLE VIII

EFFECT OF A FIFTY PER CENT CARBOHYDRATE,
1300 CALORIE DIET ON SERUM INSULIN LEVELS

Subject		F	½	1	2	3	Hour
				mu/ml			
GB	A	--	180	292	108	40	
	B	23	---	61	47	49	
RB	A	16	105	91	66	19	
	B	--	---	61	61	49	
CD	A	--	66	87	112	35	
	B	28	59	61	70	33	
HF	A	21	112	110	180	126	
	B	19	103	70	96	66	
EH	A	26	143	292	234	110	
	B	21	126	138	234	75	
JL	A	28	124	133	210	54	
	B	26	112	124	131	56	
SM	A	--	59	410	363	311	
	B	16	---	129	143	103	
KM	A	--	190	124	140	105	
	B	--	61	94	77	44	
WM	A	--	133	---	84	54	
	B	21	170	105	42	30	
EN	A	42	59	80	103	112	
	B	15	56	--	161	168	
RS	A	61	59	103	68	63	
	B	42	63	159	152	66	
JS	A	49	87	154	145	112	
	B	42	82	105	131	87	
Means	A	35	110	171	151	95	
	B	25	92	101	112	69	

A = Initial serum insulin values, week prior to study
B = Ending serum insulin values, last week of study

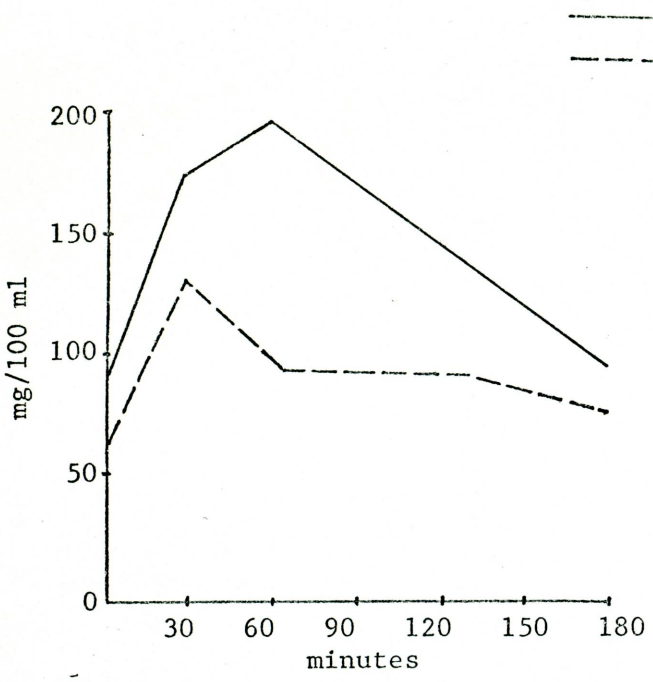

FIGURE 1

Blood Sugar Response to a
Thirty Per Cent Carbohydrate Diet
Subject GD

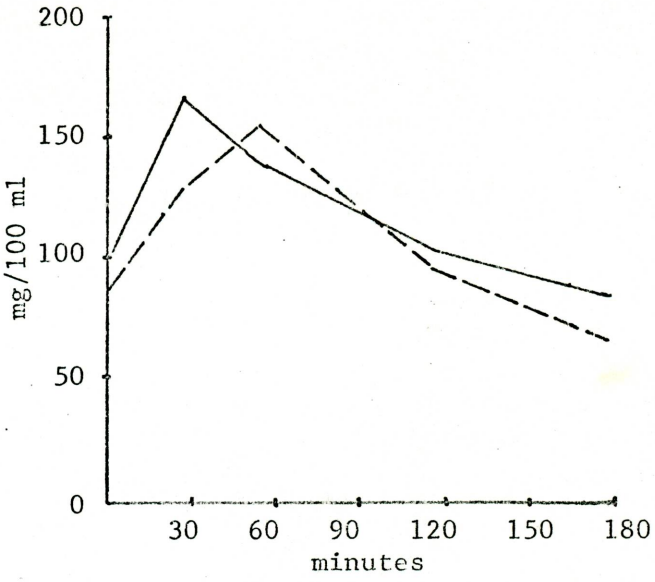

FIGURE 2

Blood Sugar Response to a
Fifty Per Cent Carbohydrate Diet
Subject GD

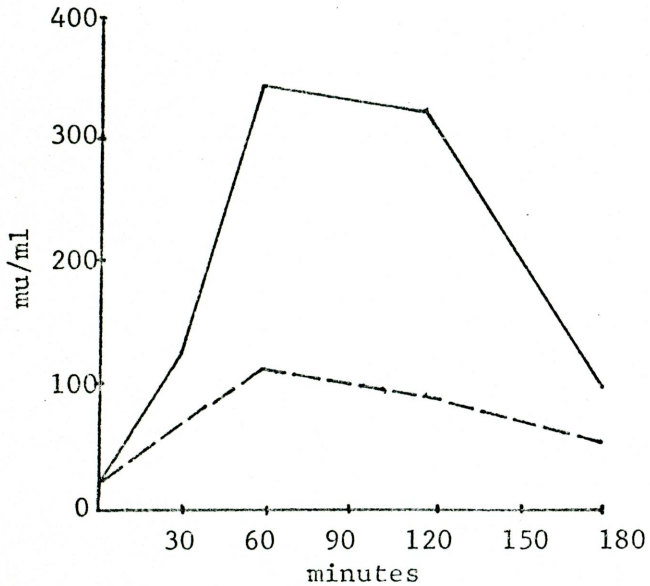

FIGURE 3

Serum Insulin Response to a
Thirty Per Cent Carbohydrate Diet
Subject GD

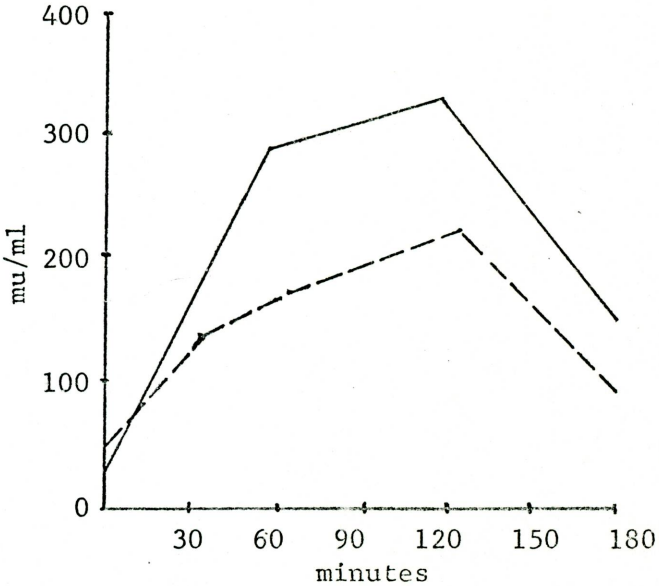

FIGURE 4

Serum Insulin Response to a
Fifty Per Cent Carbohydrate Diet
Subject GD

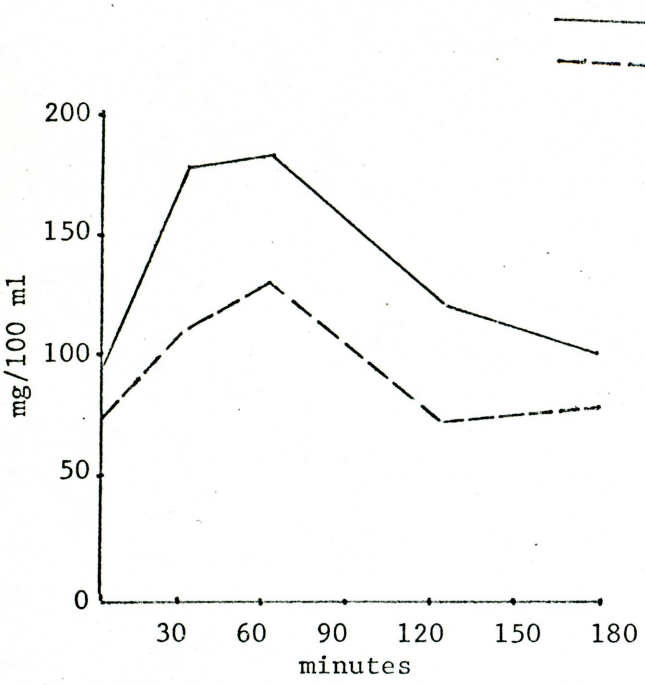

FIGURE 5

Blood Sugar Response to a
Thirty Per Cent Carbohydrate Diet
Subject MP

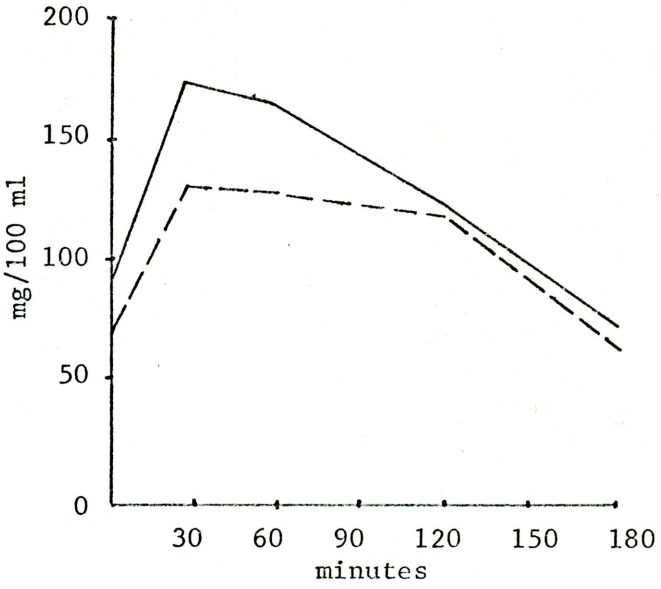

FIGURE 6

Blood Sugar Response to a
Fifty Per Cent Carbohydrate Diet
Subject MP

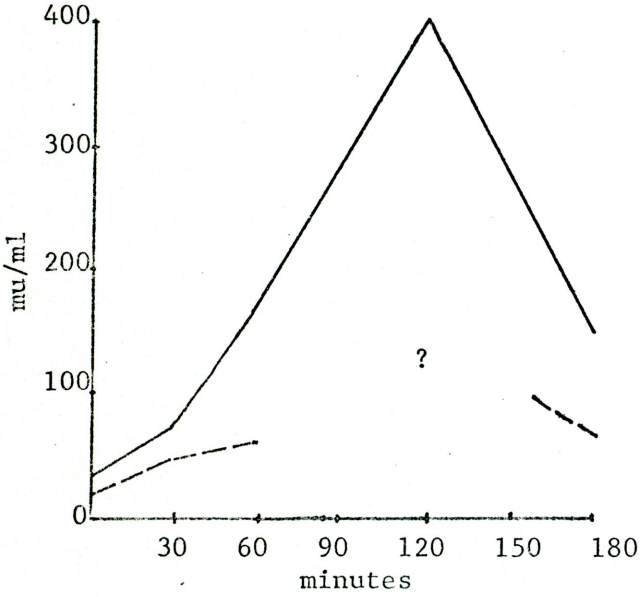

FIGURE 7

Serum Insulin Response to a
Thirty Per Cent Carbohydrate Diet
Subject MP

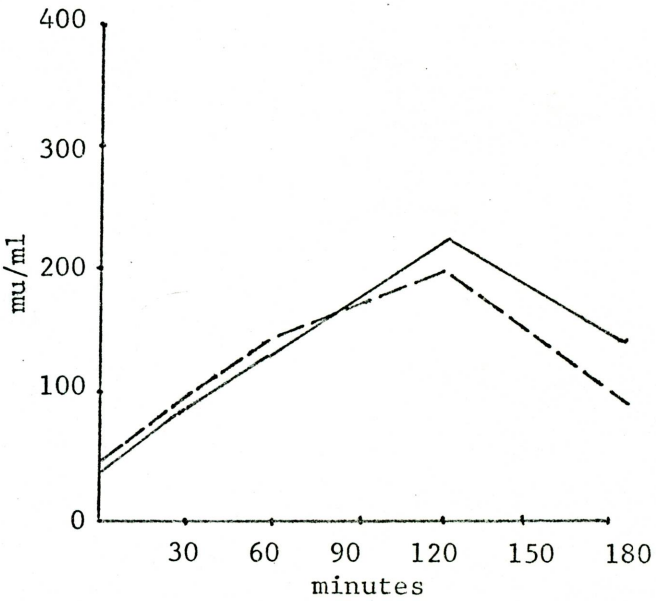

FIGURE 8

Serum Insulin Response to a
Fifty Per Cent Carbohydrate Diet
Subject MP

group to observe and compare their response to a higher level of carbohydrate.

In the 50 per cent carbohydrate group, there were four subjects with impaired glucose tolerance when determined before the five week period: subjects CD, HF, JL, and EN (Table VI, page 37). The most extreme case was subject EN. Of the remaining eight subjects, seven were normal and one (WM) showed a flat curve.

Serum insulin determinations at this time revealed excessive available insulin in subjects EH and SM (Table VIII, page 39). Subject EN had exhibited an elevated glucose tolerance curve. Serum insulin levels were moderately high in subjects GB, HF, JL, KM, and JS. Of these five, two had elevated glucose tolerance curves and three were normal.

When the glucose tolerance tests and serum insulin determinations were repeated during the final week of the study, subjects HF and JL, who had previously exhibited elevated curves showed moderate improvement. Subjects CD and EN showed no improvement. The subject (WM) with a previously flat curve, showed a slight peak after the five week period. Of the seven previously normal subjects, four remained normal, two exhibited rather flat curves (GB and RB), and one (SM) showed decreased glucose tolerance at this time.

The two subjects, GD and MP, who were again observed on the 50 per cent carbohydrate study did not exhibit abnormal glucose tolerance to the extent they had before the 30 per cent carbohydrate study period. In fact their tolerance was within the normal range at this time

(Figures 2 and 6, pages 40 and 41). There was a period of approximately three months between studies, but perhaps this period was not long enough to nullify the effects of the previous study.

At the beginning of the 50 per cent carbohydrate study period the serum insulin levels had increased considerably since the final values of the previous 30 per cent carbohydrate study, although this increase did not quite attain the initial values of that study for these two subjects (Figures 4 and 8, pages 40 and 41).

It should be pointed out that during the intervening three months, subject GD gained back all previously lost weight (12 pounds) while MP maintained constant weight. This may be a factor affecting glucose tolerance and serum insulin levels.

After the five week 50 per cent carbohydrate period, subject GD showed essentially no change in glucose tolerance; subject MP exhibited a somewhat lower curve. Serum insulin values at this time were considerably lower for GD but showed very slight variation for subject MP.

Many other investigators have observed impaired glucose tolerance in the obese.[1,33,57,76] It has been suggested that the degree of impairment may be related to either the percentage deviation from desirable weight[23] or to the duration of obesity.[44] Findings in this study upheld both these theories. It was observed that subjects with elevated glucose tolerance curves were at least 40 years of age or greater than 50 per cent overweight. These two factors seemed to work synergistically with the result that subjects of around 60 years of age, who were extremely overweight, exhibited the most abnormal glucose tolerance.

Elevated insulin levels have been reported by other investigators in obese persons,[27,41] as well as in obese animals.[11,75] Although in this study subjects with elevated levels of serum insulin did not always exhibit abnormal glucose tolerance, a majority of cases did show this tendency. The correlation seemed especially high in the 50 per cent carbohydrate group before the five week period. There was no apparent reason why some subjects exhibited this tendency while others did not.

Yalow and co-workers[76] have reported that weight loss was accompanied by remission of overt diabetes and attainment of normal glucose tolerance. At the conclusion of each five week study period, previously impaired glucose tolerances in both 30 per cent carbohydrate and 50 per cent carbohydrate groups showed improvement. In most cases this improvement reached the point of normal. There did not appear to be a greater improvement in one group than in the other. Apparently the moderate difference in carbohydrate levels between the two diets was an insignificant factor as compared to the effect of weight loss.

The reason why subjects GB and RB in the 50 per cent carbohydrate group changed from normal glucose tolerance curves previous to the five week period to rather flat curves following this period is not apparent. It seems especially peculiar that subject GB exhibited a marked decrease in serum insulin level at this time.

Change in serum insulin levels in the 30 per cent carbohydrate group fluctuated in both directions resulting in a very slight mean change. There seemed to be no correlation between changes in glucose tolerance and changes in serum insulin levels in this group.

In the 50 per cent carbohydrate group almost all serum insulin levels decreased over the five week period although this decrease did not reach a normal level in several cases. Perhaps the greater mean decrease observed in serum insulin levels in the 50 per cent carbohydrate group was the natural result of far greater initial insulin levels in this group than in the 30 per cent carbohydrate group.

It is difficult to draw conclusions from these findings because it appears that there were more persons with initially abnormal glucose tolerance and elevated serum insulin levels in the 50 per cent carbohydrate group. Regardless of this imbalance, the observations do indicate that weight loss on either diet results in some cases in a more effective supply of insulin with consequent improvement in glucose tolerance. This may be due to either an increased level of insulin or to a releasing for active participation of already available insulin thus permitting decreased levels.

Cholesterol. In both 30 per cent carbohydrate and the 50 per cent carbohydrate groups, cholesterol levels decreased in nearly all subjects over the five week dietary period. Net cholesterol changes in the 30 per cent carbohydrate group ranged from +48 to -63 mg/100 ml with a mean net change of -21 mg/100 ml which was found statistically significant at the .04 level. Net cholesterol changes in the 50 per cent carbohydrate group ranged from +8 to -96 mg/100 ml with a mean net change of -27 mg/100 ml which was statistically significant at the

.01 level. These values are listed in Tables IX and X, pages 47 and 48. The difference between the mean net change of the 30 per cent carbohydrate group and the mean net change of the 50 per cent carbohydrate group was found to be insignificant.

Many investigators have found cholesterol levels to increase on low carbohydrate diets because these diets are usually high in saturated fat.[32,36] The fat used in both diets on this study was entirely polyunsaturated with exception of the daily egg. The 30 per cent carbohydrate diet had a P/S ratio of 2.1 and the 50 per cent carbohydrate diet a P/S ratio of 1.9. This was probably an important factor in the lowering of cholesterol levels in these subjects.

Galbraith and co-workers[15] found that weight reduction resulted in a lowering of cholesterol levels regardless of saturated fat intake. Although there seems to be no correlation between pounds lost and degree of cholesterol reduction in the subjects of this study, yet weight loss is very possibly a second important factor in the lowering of these cholesterol levels.

It may be that the wide variation in net change of cholesterol levels among subjects is caused by an equally wide variation in previous dietary habits. Subjects who had previously consumed a diet high in polyunsaturates would not exhibit as drastic cholesterol reduction as subjects who had previously consumed a predominantly animal fat diet. The reason why subject LS in the 30 per cent carbohydrate group exhibited an increase of 48 mg/100 ml is not apparent. Possibly a factor apart from diet was the cause. Without this value the mean net

TABLE IX

BEGINNING AND ENDING CHOLESTEROL, FREE FATTY ACIDS, AND URIC ACID LEVELS IN THE THIRTY PER CENT CARBOHYDRATE GROUP

Subject	Cholesterol			Free Fatty Acids			Uric Acid		
	Week 1	Week 5	Change	Week 1	Week 5	Change	Week 1	Week 5	Change
	mg/100 ml			mEq/liter			mg/100 ml		
BB	162	150	-12	.89	.80	- .09	6.8	7.2	+ .4
AC	250	214	-36	1.22	1.65	+ .43	8.0	11.3	+3.3
FD	174	127	-47	.66	1.00	+ .34	3.9	3.9	0
IHa	256	193	-63	.45	.90	+ .45	3.9	4.0	+ .1
IHe	201	150	-51	.79	.49	- .30	6.9	5.4	-1.5
HN	170	154	-16	.90	.76	- .13	4.7	5.9	+1.2
MP	194	173	-21	.95	.76	- .19	6.6	6.9	+ .3
VS	174	155	-19	.72	.78	+ .06	5.5	5.7	+ .2
LS	175	223	+48	.66	1.72	+1.06	6.9	8.2	+1.3
WS	196	151	-45	.67	1.26	+ .59	6.2	7.8	+1.6
GT	200	216	+16	.77	1.33	+ .56	5.5	7.2	+1.7
CW	220	214	- 6	.91	1.52	+ .61	9.3	8.7	- .6
Mean Values	198	177	-21	.80	1.08	+ .28	6.2	6.8	+ .7
S.E. of Mean	8.8	9.6	9.0	.06	.12	.12	.46	.60	.36

TABLE X

BEGINNING AND ENDING CHOLESTEROL, FREE FATTY ACIDS, AND URIC ACID LEVELS IN THE FIFTY PER CENT CARBOHYDRATE GROUP

Subject	Cholesterol			Free Fatty Acids			Uric Acid		
	Week 1	Week 5	Change	Week 1	Week 5	Change	Week 1	Week 5	Change
	mg/100 ml			mEq/liter			mg/100 ml		
GB	324	230	-96	2.24	.84	+1.40	9.9	12.9	+3.0
RB	205	161	-44	.20			7.9	7.5	- .4
CD		141		.65	1.55	+ .90	7.1	5.4	-1.7
HF	215	202	-13	.71	1.05	+ .34	5.9	5.3	- .6
EH	244	198	-46	.73	.84	+ .11	6.6	5.9	- .7
JL	213	209	- 4	.35	.64	+ .29	4.2	3.4	- .8
SM	146	118	-28	.70	1.46	+ .76	5.6	5.6	0
KM	214	188	-26	1.24			7.6	7.5	- .1
WM	145	153	+ 8	.93	1.46	+ .53	4.8	4.7	- .1
EN	244	229	-15	.66	1.86	+1.20	6.8	5.7	-1.1
RS	165	160	- 5	.48	.64	+ .36	8.3	6.2	-2.1
JS	243	210	-33	.60	1.03	+ .43	7.0	6.5	- .5
Mean Values	214	183	-27	.79	1.14	+ .35	6.8	6.4	- .4
S.E. of Mean	15.6	10.4	8.5	.15	.13	.14	.45	.68	.36

change for the 30 per cent carbohydrate group was -27 mg/100 ml which is exactly the degree of change observed in the 50 per cent carbohydrate group.

Free fatty acids. Free fatty acids (FFA) increased slightly in both study groups. Net change in the 30 per cent carbohydrate group ranged from -.30 to +1.06 mEq/liter with a mean net change of +.28 mEq/liter which was significant at a .04 level. Net change in the 50 per cent carbohydrate group ranged from +.11 to +1.40 mEq/liter with a mean net change of +.35 mEq/liter which was found statistically insignificant. The difference between the means of the two groups approached significance at a .055 level. FFA values are listed in Tables IX and X, pages 47 and 48.

In the 30 per cent carbohydrate group eight subjects showed a net increase in FFA while four subjects showed a net decrease. In the 50 per cent carbohydrate group all subjects analyzed (ending fasting blood samples were not available for two subjects) showed net increases.

Other investigators have observed the obese to be relatively resistant to increases in FFA levels when subjected to prolonged fasting conditions.[4,41,18,46,62] If FFA are considered a sign of lipolysis, then it follows that the obese are more resistant to the mobilization of adipose stores during fasting.[46]

The four subjects in the 30 per cent carbohydrate group who exhibited decreases in FFA levels were in all cases of long-standing, extreme obesity. It could be assumed that these persons were more

resistant to lipolysis under the conditions of this diet. However, there were other subjects with comparable degrees of obesity who showed increases in FFA levels under the same conditions.

Although these results could suggest a greater and more consistent breakdown of fats on the 30 per cent carbohydrate diet than on the 50 per cent carbohydrate diet, this is probably due to individual variation since the difference in net mean changes was not found to be significant.

Uric acid. In the 30 per cent carbohydrate group, net change in uric acid levels ranged from -1.5 to +3.3 mg/100 ml with a mean net change of +0.67 mg/100 ml which was found statistically insignificant. In the 50 per cent carbohydrate group, net change in uric acid levels ranged from -2.1 to +3.0 mg/100 ml with a mean net change of -0.42 mg/100 ml which was likewise found insignificant. One subject in each group exhibited an increase considerably greater than the mean change. Changes in other subjects were less extreme. Due to individual variation, mean change in the 30 per cent carbohydrate group was not found statistically different from the mean change in the 50 per cent carbohydrate group.

The normal uric acid ranges observed in the Loma Linda University Medical Center clinical laboratory were 2.5 to 7.0 mg/100 ml for men and 1.5 to 6.0 mg/100 ml for women. The mean initial uric acid levels in both groups of this study were close to the upper limits of these values. There is evidence from recent studies that the uric acid

range presently accepted as "normal" is somewhat narrow.[74] If this report is confirmed, these subjects may well be considered within the normal range.

One investigator comparing the effect of starvation and high fat diets on uric acid levels reported mean control uric acid levels of 4.3 mg/100 ml. On a 90 per cent fat diet uric acid levels reached 11.5 mg/100 ml. Comparable results were found under fasting conditions.[63]

Another investigator who compared the effects of fasting, and high fat diets, as well as infusions of ketones into normal subjects concluded that decreased uric acid excretion with resultant serum elevations was the direct result of ketosis.[34]

Ketone bodies. Determination of urinary ketone levels by means of Ketostix following the fourth dietary week revealed minimal levels in both study groups. Two subjects in the 30 per cent carbohydrate group showed traces, one subject showed a double plus (++), while the remaining subjects exhibited no evidence of ketosis. Only one subject in the 50 per cent carbohydrate group exhibited presence of ketone bodies at a one plus (+) level; the remainder were negative.

The literature indicates a greater tendency toward ketosis on a low carbohydrate diet than on a normal or high carbohydrate diet.[2,6,18,30,32,51] The results of this study revealed only slight differences between the two carbohydrate levels observed. These results may point favorably toward a 30 per cent carbohydrate level for weight reducing diets. Apparently at this level the desirable characteristics of the

low carbohydrate regime can be retained while still avoiding the ketotic effect of an extremely low carbohydrate intake.

Satiety and subject reactions. It was evident from both the daily comment sheets as well as the spoken remarks of the subjects that between meal hunger was much greater on the 50 per cent carbohydrate diet than on the 30 per cent carbohydrate diet. Nearly all subjects in the 50 per cent carbohydrate group complained of extreme between-meal hunger every day. This seemed to be frequently accompanied by headache, weakness, and irritability. Several subjects in the 30 per cent carbohydrate group reported between meal hunger and weakness for the first few days of the study, however, after this adjustment period, there was only an occasional report of late-afternoon hunger. Symptoms of weakness and headache seemed somewhat less also. These differences could be due to individual idiosyncrasies, however, strong general trends did seem evident in both groups.

It should be pointed out, that in both dietary groups there were several subjects who reported feeling completely satisfied and even full during the entire study. In all cases these subjects were women and without exception weight loss occurred. This may be attributed to the high level of bulky, low-calorie items included in both dietary patterns, whereas these subjects may have previously taken extra calories through more concentrated foods.

As would be expected, the men in both groups felt less satisfied after meals and reported more between-meal hunger than the women in

their group. However, there were several women in both groups who frequently reported hunger and in several cases were believed to have succumbed to this desire and regularly supplemented the food allotted them during the study. These persons could be classed as "compulsive eaters." Two of the worst offenders were discussed in detail under the heading "Weight Loss."

CHAPTER IV

SUMMARY AND CONCLUSIONS

Two groups of twelve overweight subjects each (nine women; three men) consumed a 1300 calorie, highly polyunsaturated fat, lacto-ovo-vegetarian diet for a period of five weeks. One group was fed a 30 per cent carbohydrate level, and the other was fed a 50 per cent carbohydrate level which approximates the normal distribution. All meals were prepared in the Department of Nutrition's test kitchen. Weight loss, beginning and ending glucose tolerance curves in reference to beginning and ending serum insulin levels, as well as beginning and ending cholesterol, free fatty acid, and uric acid levels were compared. At the end of the fourth dietary week, urine samples were tested for presence of ketones. Relative satiety value of each diet was observed.

Total weight loss averaged 12.9 pounds in the 30 per cent carbohydrate group and 13.6 pounds in the 50 per cent carbohydrate group. No statistical difference was observed in weight loss between the women of each group, the men of each group, or between the total means for each group. Although both diets were well accepted, the satiety value of the 30 per cent carbohydrate diet was found considerably greater than that for the 50 per cent carbohydrate diet. This was considered a potential determinant of cooperation and hence weight loss. Glucose tolerance returned to normal following the 30 per cent carbohydrate diet whether the subjects had previously exhibited an elevated curve or a flat curve. Only two of the four subjects having an

initially elevated curve returned to normal on the 50 per cent carbohydrate diet, while one subject with an initially normal curve exhibited decreased glucose tolerance following this diet. Due to group imbalances in initial serum insulin levels, no conclusions could be drawn. Mean cholesterol levels decreased slightly but significantly in both groups. There was a slight but significant rise in free fatty acids in the 30 per cent carbohydrate group; change was insignificant in the 50 per cent carbohydrate group. Differences between the two groups approached significance. Changes in uric acid were insignificant and presence of ketone bodies was almost negative in both groups.

The 30 per cent carbohydrate reducing diet observed in this study holds the primary advantage of greater satiety value over the isocaloric 50 per cent carbohydrate diet.

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APPENDIX

TABLE XI

MENU FOR THIRTY PER CENT CARBOHYDRATE GROUP: DAY ONE

	Weight	Food Energy	CHO	PRO	FAT	Calcium	Iron	Vit. A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
	gm	cal.	gm	gm	gm	mg	mg	IU	mg	mg	mg	mg
Breakfast												
1 egg	48	75	.4	6.2	5.5	27	1.1	590	.05	.15	54.	--
½ slice bread	12	30	5.5	1.2	.4	12	.2	tr.	.03	.01	.3	tr.
½ pat margarine	3.5	27	--	--	3.0	tr.	--	115	--	--	--	--
3 Little Links	65	135	3.6	10.4	8.7	14	.9	--	--	--	--	--
½ tsp. oil	2.5	22	--	--	2.5	--	--	--	--	--	--	--
4 oz. orange juice	124	60	13.0	1.0	.5	11	.1	250	.11	.02	.4	56
1 Tbsp. mocha mix	15	23	1.1	.1	2.0	--	--	--	--	--	--	--
		372	23.6	18.9	22.6	64	2.3	955	.19	.18	.7	56
Lunch												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
1 slice Nuteena	75	170	6.0	9.2	12.0	27	.8	--	.01	.12	1.0	--
1/3 cup tomato juice	50	10	2.0	.4	.1	3	.4	400	.03	.02	.4	8
1/3 cup cottage cheese with D-Zerta	75	82	2.2	11.2	3.2	72	.2	130	.02	.18	.1	--
½ cup green beans	75	30	4.0	1.1	.1	33	1.2	318	.02	.04	.2	3
½ slice bread	12	30	5.5	1.2	.4	12	.2	tr.	.03	.01	.3	tr.
1 pat margarine	7	54	--	--	6.0	tr.	--	230	--	--	--	--
		441	29.1	29.7	21.9	371	2.9	1086	.19	.70	2.2	13
Supper												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
2 Dinner Cuts	100	100	4.4	16.9	1.8	40	1.7	--	.01	.23	.9	--
2/3 tsp. oil	2.6	23	--	--	2.6	--	--	--	--	--	--	--
½ cup tossed salad	50	9	1.5	.6	.1	10	.2	160	.03	.03	.1	3
Vegecheese strips	40	62	.6	5.8	4.0	--	--	--	--	--	--	--
1 Tbsp. salad dressing	15	45	--	--	5.0	--	--	--	--	--	--	--
½ cup cauliflower	85	22	3.6	1.8	--	19	.6	60	.08	.07	.5	40
½ small baked potato	100	80	17.1	2.6	.1	7	.6	tr.	.10	.04	1.4	20
1 pat margarine	7	54	--	--	6.0	tr.	--	230	--	--	--	--
½ cup sliced peaches	100	34	8.2	.4	--	4	.3	450	.01	.03	.6	3
		494	44.8	34.7	19.7	304	3.5	908	.31	.73	3.7	68
DAILY TOTALS		1307	97.5	83.3	64.2	739	8.7	2949	.69	1.61	6.6*	137

*Add 13.9 mg niacin equivalents calculated from tryptophan

TABLE XII

MENU FOR THIRTY PER CENT CARBOHYDRATE GROUP: DAY TWO

	Weight	Food Energy	CHO	PRO	FAT	Calcium	Iron	Vit. A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
	gm	cal.	gm	gm	gm	mg	mg	IU	mg	mg	mg	mg
Breakfast												
1 egg	48	75	.4	6.2	5.5	27	1.1	590	.05	.15	tr.	--
½ slice bread	12	30	5.5	1.2	.4	12	.2	tr.	.03	.01	.3	tr.
½ pat margarine	3.5	27	--	--	3.0	tr.	--	115	--	--	--	--
6 Tender bits	100	123	7.2	11.9	5.2	34	1.6	--	--	--	--	--
1 tsp. oil	5	45	--	--	5.0	--	--	--	--	--	--	--
½ cup applesauce	100	46	10.8	.2	.2	4	.5	40	.02	.01	tr.	1
1 Tbsp. mocha mix	15	23	1.1	.1	2.0	--	--	--	--	--	--	--
		369	25.0	19.6	21.3	77	3.4	745	.10	.17	.3	1
Lunch												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
2½ Linketts	100	206	2.4	19.6	13.1	51	2.1	--	.03	.35	2.0	--
½ cup spinach	90	26	3.0	2.5	.5	106	2.3	7200	.02	.10	.3	12
½ banana with D-Zerta	75	48	11.5	.5	--	4	.3	95	.02	.03	.3	5
1 slice bread	23	60	11.0	2.4	.8	23	.4	tr.	.06	.02	.6	tr.
1 pat margarine	7	54	--	--	6.0	tr.	--	230	--	--	--	--
		459	37.3	31.6	20.5	408	5.2	7533	.21	.83	3.4	19
Supper												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
1 cup vegetable soup	246	18	3.0	1.5	--	5	.8	600	.08	.07	.6	6
1 slice soy fiber entree	50	112	2.7	10.2	6.6	20	.9	--	--	--	--	--
6 spears asparagus	80	18	3.2	1.2	.1	15	.4	600	.10	.13	1.0	19
1 Tbsp. mayonnaise	15	108	--	--	12.0	3	.1	40	tr.	.01	tr.	--
1 tomato	150	36	7.0	2.0	--	20	.8	1350	.10	.06	1.0	34
¼ cup cottage cheese	60	63	1.7	8.2	2.5	60	.2	100	.02	.14	tr.	--
3 Saltine crackers	8	37	6.0	1.0	1.0	2	.1	--	tr.	tr.	.1	--
Lettuce	50	9	1.5	.6	.1	10	.2	160	.03	.03	.1	3
		466	34.5	31.3	22.4	359	3.6	2858	.41	.77	3.0	64
DAILY TOTALS		1294	96.8	82.5	64.2	844	12.2	11136	.72	1.77	6.7*	84

*Add 13.8 mg niacin equivalents calculated from tryptophan

TABLE XIII

MENU FOR THIRTY PER CENT CARBOHYDRATE GROUP: DAY THREE

	Weight	Food Energy	CHO	PRO	FAT	Calcium	Iron	Vit. A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
	gm	cal.	gm	gm	gm	mg	mg	IU	mg	mg	mg	mg
Breakfast												
1 egg	48	75	.4	6.2	5.5	27	1.1	590	.05	.15	tr.	--
½ slice Proteena	50	100	2.8	10.7	5.0	20	.8	17	.04	.27	1.0	--
½ tsp. oil	2.5	22	--	--	2.5	--	--	--	--	--	--	--
½ slice bread	12	30	5.5	1.2	.4	12	.2	tr.	.03	.01	.3	tr.
½ pat margarine	3.5	27	--	--	3.0	tr.	--	115	--	--	--	--
½ grapefruit	285	60	14.0	1.0	--	22	.6	10	.05	.02	.2	52
1 Tbsp. mocha mix	15	23	1.1	.1	2.0	--	--	--	--	--	--	--
		337	23.8	19.2	18.4	81	2.7	732	.17	.45	1.5	52
Lunch												
6 oz. non-fat milk	183	65	9.3	6.6	.1	224	.1	8	.08	.33	.2	2
½ cup Vegeburger	80	93	3.4	15.4	2.0	35	1.3	--	.13	.14	1.8	--
2 Tbsp. tomato juice	20	4	.8	.1	--	1	.2	150	.01	.01	.2	3
1½ tsp. oil	7.5	68	--	--	7.5	--	--	--	--	--	--	--
½ cup zucchini	105	18	3.5	1.0	--	26	.4	410	.05	.08	.8	10
½ cup tossed salad	50	9	1.5	.6	.1	10	.2	160	.03	.03	.1	3
11 med. pitted olives	25	45	--	--	5.0	22	.2	30	tr.	tr.	--	--
1 slice bread	23	60	11.0	2.4	.7	23	.4	tr.	.06	.02	.6	tr.
½ pat margarine	3.5	18	--	--	3.0	tr.	--	115	--	--	--	--
½ apple	75	36	9.0	--	--	4	.2	25	.02	.01	tr.	2
		416	38.5	26.1	18.4	345	3.0	898	.38	.62	3.7	20
Supper												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
2 Dinner Cuts	100	105	4.4	16.9	1.8	40	1.7	--	.01	.23	.9	--
¼ cup Gravy Quik	60	22	4.3	.9	.1	--	--	--	--	--	--	--
½ cup green beans	75	30	4.2	1.5	--	28	1.1	245	.03	.04	.3	3
½ cup mashed potatoes	100	202	13.0	2.1	15.7	24	.4	25	.08	.05	1.0	9
1 pat margarine	7	54	--	--	6.0	tr.	--	230	--	--	--	--
3 cot. ch. filled celery	50	56	1.5	7.6	2.2	50	.2	90	.02	.12	tr.	--
		534	36.8	35.7	25.9	366	3.5	598	.22	.77	2.4	14
DAILY TOTALS		1287	99.1	80.9	62.7	792	9.2	2228	.77	1.84	7.6*	86

*Add 13.5 mg niacin equivalents calculated from tryptophan

TABLE XIV

MENU FOR THIRTY PER CENT CARBOHYDRATE GROUP: DAY FOUR

	Weight	Food Energy	CHO	PRO	FAT	Calcium	Iron	Vit. A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
	gm	cal.	gm	gm	gm	mg	mg	IU	mg	mg	mg	mg
Breakfast												
1 egg	48	75	.4	6.2	5.5	27	1.1	590	.05	.15	tr.	--
1 slice bread	23	60	11.0	2.4	.8	23	.4	tr.	.06	.02	.6	tr.
1 pat margarine	7	54	--	--	6.0	tr.	--	230	--	--	--	--
2 Linketts	75	154	1.8	14.7	9.8	38	1.6	--	.02	.26	1.5	--
½ tsp. oil	2.5	22	--	--	2.5	--	--	--	--	--	--	--
½ cup apricot halves	100	42	9.6	.7	.1	12	.3	1830	.02	.02	.4	4
1 Tbsp. Mocha mix	15	23	1.1	.1	2.0	--	--	--	--	--	--	--
		430	23.9	24.1	26.7	100	3.4	2650	.15	.45	2.5	4
Lunch												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
2 Dinner cuts	75	75	3.3	12.5	1.3	30	1.3	--	.01	.18	.6	--
1½ tsp. oil	7.5	68	--	--	7.5	--	--	--	--	--	--	--
1/3 cup tomato juice	50	10	2.1	.4	.1	3	.4	400	.03	.02	.4	8
½ cup broccoli	75	26	3.5	2.5	.2	66	.6	675	.06	.15	.6	72
½ slice bread	12	30	5.5	1.2	.4	12	.2	tr.	.03	.01	.3	tr.
1 pat margarine	7	54	--	--	6.0	--	--	--	--	--	--	--
raw vegetable salad	60	25	4.0	1.0	--	10	.2	3000	.03	.03	.1	3
		353	27.8	24.2	15.6	345	2.8	4083	.24	.72	2.2	85
Supper												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
2 slices soy fiber entree	60	130	3.1	11.9	7.8	22	1.1	--	--	--	--	--
small bunch grapes	70	47	11.0	.4	.2	7	.2	60	.03	.02	.2	2
2 rings pineapple	70	40	9.5	.5	tr.	12	.3	50	.06	.02	.1	12
½ cup cottage cheese	75	82	2.9	11.2	3.2	72	.2	130	.02	.18	.1	--
lettuce	50	9	1.5	.6	.1	10	.2	160	.03	.03	.1	3
½ slice bread	12	30	5.5	1.2	.4	12	.2	tr.	.03	.01	.3	tr.
1 Tbsp. mayonnaise	15	110	tr.	tr.	12.0	3	.1	40	tr.	.01	tr.	--
		513	42.9	32.4	23.8	362	1.4	448	.25	.60	1.0	19
DAILY TOTALS		1296	94.6	80.7	66.1	807	7.6	7181	.64	1.77	5.7*	108

*Add 13.4 mg niacin equivalents calculated from tryptophan

TABLE XV

MENU FOR FIFTY PER CENT CARBOHYDRATE GROUP: DAY ONE

	Weight	Food Energy	CHO	PRO	FAT	Calcium	Iron	Vit. A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
	gm	cal.	gm	gm	gm	mg	mg	IU	mg	mg	mg	mg
Breakfast												
1 egg	48	75	.4	6.2	5.5	27	1.1	590	.05	.15	tr.	--
1 slice bread	23	60	11.0	2.4	.8	23	.4	tr.	.06	.02	.6	tr.
2 Little Links	43	90	2.4	6.9	5.8	20	1.1	--	--	--	--	--
8 oz. orange juice	246	120	26.0	2.0	1.0	22	.2	500	.22	.04	.8	112
2 oz. non-fat milk	60	22	3.1	2.2	--	75	tr.	3	.03	.11	.1	1
1 Tbsp. Mocha mix	15	23	1.1	.1	2.0	--	--	--	--	--	--	--
½ cup dry cereal	14	55	11.0	2.0	.3	2	.2	--	.06	.01	.3	--
		445	55.0	21.8	15.4	169	3.0	1093	.22	.33	1.8	113
Lunch												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
½ small baked potato	110	88	18.8	2.8	.1	8	.7	tr.	.11	.04	1.5	22
1 cup vegetable soup	246	18	3.0	1.5	--	5	.8	600	.08	.07	.6	6
¼ cup cottage cheese with D-Zerta	60	63	1.7	8.2	2.5	60	.2	100	.02	.14	tr.	--
½ cup green peas	75	52	8.9	3.8	.2	17	1.3	420	.20	.08	1.7	15
1 slice bread	23	60	11.0	2.4	.8	23	.4	tr.	.06	.02	.6	tr.
1½ pats margarine	10.5	81	--	--	9.0	tr.	--	345	--	--	--	--
		427	52.8	25.3	12.7	337	3.5	473	.55	.68	4.6	45
Supper												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
1 slice Nuteena	75	170	6.0	9.2	12.0	27	.9	--	.01	.12	1.0	--
½ cup thickened tomato j.	75	15	3.0	3.6	.2	4	.6	600	.04	.03	.6	12
½ cup cauliflower	85	22	3.6	1.8	--	19	.6	60	.08	.07	.5	40
½ cup tossed salad	50	9	1.5	.6	.1	10	.2	160	.03	.03	.1	3
1 slice bread	23	60	11.0	2.4	.8	23	.4	tr.	.06	.02	.6	tr.
½ pat margarine	3.5	27	--	--	3.0	tr.	--	115	--	--	--	--
3/4 cup peaches	150	47	12.3	.6	--	6	.4	675	.02	.04	.8	4
		415	46.8	24.8	16.2	313	3.2	1618	.32	.64	3.8	61
DAILY TOTALS		1287	154.6	71.9	44.3	819	9.7	3184	1.09	1.65	10.2*	219

*Add 12.0 mg niacin equivalents calculated from tryptophan

TABLE XVI

MENU FOR FIFTY PER CENT CARBOHYDRATE GROUP: DAY TWO

	Weight	Food Energy	CHO	PRO	FAT	Calcium	Iron	Vit. A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
	gm	cal.	gm	gm	gm	mg	mg	IU	mg	mg	mg	mg
Breakfast												
1 egg	48	75	.4	6.2	5.5	27	1.1	590	.05	.15	tr.	--
1 slice bread	23	60	11.0	2.4	.7	23	.4	tr.	.06	.02	.6	tr.
½ slice Proteena	50	70	2.0	7.5	3.5	20	.7	17	.04	.27	1.0	--
1/3 tsp. oil	1.7	15	--	--	1.7	--	--	--	--	--	--	--
½ grapefruit	285	60	14.0	1.0	--	22	.6	10	.05	.02	.2	52
1 cup dry cereal	28	110	22.0	4.0	.6	4	.4	--	.12	.02	.6	--
2 oz. non-fat milk	60	22	3.1	2.2	--	75	tr.	3	.03	.11	.1	1
1 Tbsp. Mocha Mix	15	23	1.1	.1	2.0	--	--	--	--	--	--	--
		435	53.6	23.4	14.0	171	3.2	620	.35	.59	2.5	53
Lunch												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
1 sm. baked sweet potato	100	133	32.5	.5	2.1	40	.9	8100	.09	.07	.7	22
½ cup green beans	70	28	3.6	.9	--	30	1.1	300	.02	.04	.2	3
1 stuffed tomato	150	36	7.0	2.0	--	20	.8	1350	.10	.06	1.0	34
with cottage cheese	75	82	2.2	11.2	3.2	72	.2	130	.02	.18	.1	--
1½ pats margarine	10	81	--	--	9.0	--	--	--	--	--	--	--
		425	54.7	21.2	14.4	386	3.1	9888	.31	.68	2.2	61
Supper												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
½ cup Vegeburger	65	73	2.5	12.3	1.6	--	--	--	--	--	--	--
2 Tbsp. tomato juice	20	4	.3	.1	--	1	.2	150	.01	.01	.2	3
1¼ tsp. oil	6.5	60	--	--	6.5	--	--	--	--	--	--	--
½ cup carrots	75	26	5.3	.7	.2	24	.4	7800	.04	.04	.4	5
½ burger bun	31	75	13.8	3.0	.9	31	.6	tr.	.09	.03	.9	tr.
½ cup tossed salad	50	9	1.5	.6	.1	10	.2	160	.03	.03	.1	3
1 Tbsp. salad dressing	15	45	--	--	5.0	--	--	--	--	--	--	--
1 medium apple	150	72	21.0	--	--	8	.4	50	.04	.02	tr.	4
		429	53.8	23.3	14.4	298	1.9	8168	.29	.46	1.8	17
DAILY TOTALS		1289	162.1	67.9	42.8	855	8.2	18676	.95	1.73	6.5*	131

*Add 11.3 mg niacin equivalents calculated from tryptophan

TABLE XVII

MENU FOR FIFTY PER CENT CARBOHYDRATE GROUP: DAY THREE

	Weight	Food Energy	CHO	PRO	FAT	Calcium	Iron	Vit. A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
	gm	cal.	gm	gm	gm	mg	mg	IU	mg	mg	mg	mg
Breakfast												
1 egg	48	75	.4	6.2	5.5	27	1.1	590	.05	.15	tr.	--
1 slice bread	23	60	11.0	2.4	.8	23	.4	tr.	.06	.02	.6	tr.
1 Linkett	40	103	1.1	7.8	5.2	18	.9	--	.01	.15	.8	--
½ cup apricot halves	125	53	12.0	.9	.1	15	.4	2280	.03	.03	.5	5
1 cup dry cereal	28	110	22.0	2.6	.6	4	.4	--	.12	.02	.6	--
3 oz. non-fat milk	90	32	4.6	3.3	--	112	tr.	4	.04	.16	.1	1
1 Tbsp. Mocha Mix	15	23	1.1	.1	2.0	--	--	--	--	--	--	--
		456	52.2	23.3	14.2	199	3.2	2874	.31	.53	2.6	6
Lunch												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
1 Dinner Cut	45	48	2.1	7.8	.8	20	.8	--	--	.12	.4	--
¼ cup Gravy Quik	60	22	4.3	.9	.1	--	--	--	--	--	--	--
½ cup broccoli	75	26	3.5	2.5	.2	66	.6	675	.06	.15	.6	72
½ cup mashed potato	120	125	15.6	2.1	6.0	28	.5	20	.10	.06	1.2	11
1 cup Chef's salad	60	9	5.0	1.0	.1	10	.2	160	.03	.03	.1	3
1 slice bread	23	60	11.0	2.4	.8	23	.4	tr.	.06	.02	.6	tr.
1 pat margarine	7	54	--	--	6.0	tr.	--	230	--	--	--	--
		409	50.9	23.3	14.1	371	2.6	1093	.33	.71	3.1	88
Supper												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
1/3 cup cottage cheese	60	63	1.7	8.2	2.5	60	.2	100	.02	.14	tr.	--
½ cup frozen strawberries	75	30	6.3	.6	.3	15	.7	45	.02	.05	.5	75
2 rings pineapple	70	40	9.5	.5	tr.	12	.3	50	.06	.02	.1	12
2 pear halves	75	26	6.2	.1	.1	4	.2	tr.	.01	.02	.1	1
fresh orange slices	100	57	12.7	1.3	.1	40	.4	200	.10	.04	.4	60
1 leaf lettuce	50	9	1.5	.6	.1	10	.2	160	.03	.03	.1	3
1 Tbsp. Lo-Cal Dream Whip	15	45	--	--	5.0	--	--	--	--	--	--	--
1 slice bread	23	60	11.0	2.4	.8	23	.4	tr.	.06	.02	.6	tr.
1 pat margarine	7	54	--	--	6.0	tr.	--	230	--	--	--	--
		449	58.3	20.3	15.0	388	2.5	793	.38	.65	2.0	153
DAILY TOTALS		1314	161.4	66.9	43.3	958	7.3	4760	1.02	1.79	7.7*	247

*Add 11.2 mg niacin equivalents calculated from tryptophan

TABLE XVIII

MENU FOR FIFTY PER CENT CARBOHYDRATE GROUP: DAY FOUR

	Weight	Food Energy	CHO	PRO	FAT	Calcium	Iron	Vit. A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
	gm	cal.	gm	gm	gm	mg	mg	IU	mg	mg	mg	mg
Breakfast												
1 egg	48	75	.4	6.2	5.5	27	1.1	590	.05	.15	tr.	--
1 slice bread	23	60	11.0	2.4	.8	23	.4	tr.	.06	.02	.6	tr.
6 Tender Bits	75	83	5.4	8.9	3.9	25	1.2	--	--	--	--	--
1/3 tsp. oil	1.7	15	--	--	1.7	--	--	--	--	--	--	--
½ cup applesauce	100	46	10.8	.2	.2	4	.5	40	.02	.01	tr.	1
1 cup dry cereal	28	110	22.0	2.7	.6	4	.4	0	.12	.02	.6	--
2 oz. non-fat milk	60	22	3.1	2.2	0	75	tr.	3	.03	.11	.1	1
1 Tbsp. Mocha Mix	15	23	1.1	.1	2.0	--	--	--	--	--	--	--
		434	53.8	22.7	14.7	158	3.6	633	.28	.31	1.3	2
Lunch												
6 oz. non-fat milk	183	65	9.3	6.6	.1	224	.1	8	.08	.33	.2	2
1 slice soy fiber entree	60	130	3.1	11.9	7.8	22	1.1	--	--	--	--	--
6 spears asparagus	80	18	2.4	.9	.1	15	.4	600	.10	.13	1.0	19
½ cup steamed rice	100	105	24.2	2.0	.1	10	.9	--	.11	--	1.0	--
¼ cup Gravy Quik	60	22	4.3	.9	.1	--	--	--	--	--	--	--
½ banana with D-Zerta	75	48	11.5	.5	--	4	.3	95	.02	.03	.3	5
1 pat margarine	7	54	--	--	6.0	tr.	--	230	--	--	--	--
		442	54.8	22.8	14.2	275	2.8	933	.31	.49	2.5	26
Supper												
6 oz. non-fat milk	183	65	9.4	6.6	.1	224	.1	8	.08	.33	.2	2
½ cup corn	100	92	18.8	3.0	.5	3	.8	350	.09	.06	1.5	5
½ cup green beans	75	30	4.2	1.2	.1	33	1.2	318	.02	.04	.2	3
3 cot. ch. filled celery	60	63	1.7	8.2	2.5	60	.2	100	.02	.14	tr.	--
2/3 cup apricots	110	47	10.6	.8	.1	13	.3	2000	.02	.02	.4	4
1 slice bread	23	60	11.0	2.4	.8	23	.4	tr.	.06	.02	.6	tr.
1½ pats margarine	10	81	--	--	9.0	tr.	--	345	--	--	--	--
		438	55.7	22.2	13.1	356	3.0	3121	.29	.61	2.9	14
DAILY TOTALS		1314	164.3	67.7	42.0	789	9.4	4687	.88	1.41	6.7*	42

*Add 11.3 mg niacin equivalents calculated from tryptophan

Name _____

Address: Home _____ Phone _____

Work _____ Phone _____

Hours of work _____

Age _____ Sex _____ Height _____ Weight _____

How long have you been overweight? _____

Are parents or close relatives overweight? _____

Your present occupation? _____

Do you engage in periods of regular exercise? Yes No

If so, to what extent? _____

Have you ever been on a reducing diet before? Yes No

If so, (a) for how long? _____ (b) what success? _____

How often do you snack between meals?

(a) regularly (b) occasionally (c) very seldom (d) never

Are you allergic to any foods? Yes No List: _____

Is meat an item in your meal pattern? Yes No

Do you enjoy eating the Loma Linda vegetable entree products? Yes No

Comments _____

Does your daily schedule permit regular meal breaks? Yes No

Are you presently on any medication? ACTH _____ Thyroid _____

Insulin _____ Other _____

Please indicate your acceptance of the following foods:

	ENJOY	FAIR	DISLIKE WILL EAT	DISLIKE WON'T EAT
Cottage cheese				
Non-fat milk				
Eggs				
Broccoli				
Spinach				
Asparagus				
Green beans				
Carrots				
Tomato				

FIGURE 9

APPLICATION FORM USED IN SELECTION OF SUBJECTS

Since this research is for a master's thesis, we need to know how valid our data is. We also need your helpful suggestions for future studies. We want original ideas and honest answers--so please fill this out without group consultation, and PLEASE DO NOT SIGN YOUR NAME.

1. Please list the food items you enjoyed the most:

2. Which items did you enjoy the least?

3. Have you always eaten all food items provided in your meals here?

   Yes No If not, please list items:

4. At any time during this study, have you eaten anything not supplied by us? Yes No

   If so, a) How often (be very specific):

   b) What foods:

   c) How much each time:

5. Do you have any suggestions for changes you think should be made in future studies of this kind?

FIGURE 10

QUESTIONNAIRE GIVEN TO SUBJECTS AT CONCLUSION OF WEIGHT REDUCTION STUDIES

LOMA LINDA UNIVERSITY

Graduate School

COMPARISON OF WEIGHT REDUCTION OF HUMAN SUBJECTS FED 1300 CALORIE, LACTO-OVO-VEGETARIAN DIETS WITH TWO LEVELS OF CARBOHYDRATE

by

Margaret L. Kemmerer

An Abstract of a Thesis

In Partial Fulfillment of the Requirements

for the Degree Master of Science

in the Field of Nutrition

June 1968

The effects of 1300 calorie, high-polyunsaturated fat, lacto-ovo-vegetarian diets with two carbohydrate levels (30 per cent and 50 per cent of the total calories) were observed in two matched, twelve-subject groups over five week periods. Weight loss, satiety value, urinary ketone levels, as well as changes in glucose tolerance, serum insulin, cholesterol, free fatty acid, and uric acid levels were compared. Total weight loss averaged 12.9 pounds in the 30 per cent carbohydrate group and 13.6 pounds in the 50 per cent carbohydrate group. Differences were not significant. Satiety value of the lower carbohydrate diet was considerably greater. This was considered a potential determinant of cooperation and hence weight loss. Glucose tolerance improved somewhat more on the 30 per cent carbohydrate diet. Due to group imbalances in initial serum insulin levels, no conclusions could be drawn. Cholesterol decreased slightly but significantly on both diets. Changes in uric acid and presence of ketone bodies were found insignificant. On the 30 per cent carbohydrate diet a slight but significant increase in FFA occurred. Differences in FFA increases approached significance between groups. It was concluded that the 30 per cent carbohydrate reducing diet observed in this study held primarily the advantage of greater satiety value over the isocaloric 50 per cent carbohydrate diet.