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Effect On Energy Expenditure Of An Isocaloric, Isonitrogeneous Substitution Of High-Carbohydrate Diet Vs. A High-Fat Diet In Healthy, Middle-Aged, Caucasian Women.

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EFFECT ON ENERGY EXPENDITURE OF AN ISOCALORIC, ISONITROGENEOUS SUBSTITUTION OF HIGH CARBOHYDRATE DIET VS. A HIGH FAT DIET IN HEALTHY, MIDDLE-AGED, CAUCASIAN WOMEN

by

AXEL KENNETH OLSON

A DISSERTATION

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Nutrition Sciences in the Graduate School, The University of Alabama at Birmingham

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ABSTRACT OF DISSERTATION
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Title Effect on Energy Expenditure of an Isocaloric, Isonitrogeneous Substitution of High Carbohydrate Diet vs. a High Fat Diet in Healthy, Middle-aged, Caucasian Women

The effect of an isocaloric, isonitrogenous high carbohydrate (66%) - low fat (20%) diet (HC) vs a high fat (56%) - low carbohydrate (30%) diet (HF) on energy expenditure at maintenance energy intake was studied in 13 healthy, never-obese, postmenopausal, Caucasian females for 22 days each in crossover design. Fat-free mass (FFM) and fat mass (FM) were measured by underwater weighing before and after each diet. Resting metabolic rate (RMR) was measured fasting and for five 40-minute periods over 6 hours postprandially (i.e., diet-induced thermogenesis or DIT) after each diet. The DIT liquid meal challenge was given at 14.3 kg/FFM and was of either HC or HF composition. Within and between diet changes in glucose, insulin, glucagon, free fatty acids (FFA), cholesterol, triglycerides, T_4, and T_3 were measured. Postprandial changes in glucose, insulin, glucagon, and free fatty acids over 6 hours were also measured.

Subjects had a statistically significant weight loss (mean = 0.47 kg) after the HC diet. No significant weight changes were measured after the HF diet. No significant changes were measured for FFM or FM. RMR did not show an increase after the HC diet. A

non-significant trend was seen for DIT to be greater after the HC meal challenge.

After the HC diet the respiratory quotient (RQ), carbohydrate oxidation, and protein balance increased significantly, while fat oxidation and protein oxidation decreased. After the HF diet the opposite trend was observed. Five of 12 subjects were in negative nitrogen balance after HF. Biochemical measurements within and between diets were statistically insignificant or were physiologically appropriate. In conclusion, diet composition at physiologic intakes in healthy, middle-aged, Caucasian women can alter total body weight and influence substrate oxidation patterns. The mechanisms were not defined by the present data.

Abstract Approved by: **Committee Chairman** _____

Program Director _____

Date 1/11/95 **Dean of Graduate School** _____

PS-5744

DEDICATION

This dissertation is dedicated with deepest love, devotion, and appreciation to my wife, Spring Joy, to my children, Brea Joy, Tyler Hampton Carl, and Brynn Joy, and to my parents, Carl and Mary Larson. It is also dedicated in loving memory to my grandmother, Adeline Apa, and to my parents-in-law, Gurney and Miriam Stidham.

Without the love, patience, understanding, and sacrifice from all, this work could not have been started let alone brought to completion.

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LIST OF ABBREVIATIONS

BMC	Baptist Medical Center
BMI	Body Mass Index
CRGA	Continuous Respiratory Gas Analyzer
DIT	Diet-Induced Thermogenesis
FFM	Fat-Free Mass
FM	Fat Mass
FQ	Food Quotient
GCRC	General Clinical Research Center
HC	High Carbohydrate-Low Fat
HF	High Fat-Low Carbohydrate
KCAL	Kilocalories
KG	Kilograms
RMR	Resting Metabolic Rate
RQ	Respiratory Quotient
TEE	Total Energy Expenditure
UAB	University of Alabama at Birmingham

INTRODUCTION

It is well accepted clinically that the causes of obesity are multifactorial and that the metabolic and physiologic associates of obesity are highly complex. Irrespective of the etiology of obesity, it is also accepted that the laws of thermodynamics are adhered to in terms of metabolic energy balance (26, 39, 90). Therefore, if energy intake exceeds energy expenditure, a positive energy balance results in energy storage and, hence, obesity (9, 13, 78, 90). Because of this, the major clinical strategy for weight reduction has been caloric restriction. Much less attention has been given clinically to weight reduction strategies which consider the source of calories, i.e., diet composition in terms of the percentage of carbohydrate, fat, and protein content. This primary focus on calorie content only with lesser attention to diet composition implies that "a calorie is a calorie" and that all substrates are handled metabolically in an equally efficient manner.

However, numerous epidemiologic studies (9, 17, 45, 76) on diet composition and obesity as well as animal(4, 8, 9, 11, 16, 18, 19, 20, 21, 25-28, 33, 37, 38, 42, 47, 50, 52, 54, 55, 59, 61, 64, 66, 77, 78, 80-85, 92, 93, 99) and human studies (89, 91) on experimental obesity suggest that diet

composition, especially in terms of the carbohydrate and fat content, may indeed have different metabolic effects on energy balance because of different metabolic efficiencies with which these respective substrates are handled by the body. Specifically, it is suggested that dietary fat is stored more efficiently than dietary carbohydrate (16, 22). For example, the storage of dietary fatty acids to triglyceride in adipose tissue requires only 3% of ingested calories as the obligatory metabolic cost expressed in terms of energy expenditure (22, 23). On the other hand the cost to store dietary carbohydrate as glycogen has an obligatory metabolic expenditure of 7% of ingested kilocalories whereas the obligatory metabolic expenditure to store carbohydrate as fat is 23% of ingested kilocalories (13, 22, 23, 90). Presumably, then, a diet high in fat may be viewed as a more energy efficient diet because of the lesser obligatory metabolic energy expenditure as compared to a diet high in carbohydrate. Therefore, the possibility exists that, in an isocaloric comparison, the high fat diet may predispose more readily to obesity development and retard efforts for weight maintenance and weight reduction (13, 16, 22, 90).

Epidemiologic Studies Regarding Diet Composition, Caloric Intake, and Obesity

Numerous epidemiologic studies regarding diet composition and obesity have demonstrated a positive association between diet composition in terms of fat content and the prevalence of obesity (9, 17, 45, 76). This has been noted especially in

Western societies where dietary fat intake may be in excess of 40% of calories ingested (9). In addition, as will be discussed later, this association between fat intake and obesity may be independent of caloric intake (17, 76).

Since 1900 the United States population has decreased carbohydrate intake by 25% - 30% (49) while fat intake has increased by 25% during approximately the same time (48). Interestingly, this has occurred while the average calorie intake has declined by at least 3% (17). Also, this is associated with an increase in the average weight/height ratio of the United States population (9, 17). Additionally, cross-cultural studies have supported the observation that higher dietary fat intake is associated with an increased occurrence of obesity. For example, immigrants from Japan and from Ireland living in the United States have both a higher fat intake and a greater prevalence of obesity compared to their respective family counterparts living in their home countries (9). Also, the Chinese consume approximately 15% of total calories from fat compared to approximately 40% fat intake by Westerners and eat 20% more total calories than Westerners (75). Despite this, obesity is rare in China but is approximately 25% in Western society (97). These epidemiologic studies suggest that there may be a higher efficiency and a greater ease with which fat is stored in human subjects who consume a high fat-low carbohydrate diet

compared to those who consume a high carbohydrate-low fat diet, assuming levels of exercise are comparable.

Romieu et al. (76) have reviewed several cross-sectional studies which have reported an inverse relationship between energy intake and obesity. These data, however, may be confounded by several factors including at least the following:

1. systematic underestimating food intake by obese subjects
2. varying level of physical activity in the obese
3. age (i.e., obesity increases while caloric intakes decrease with age)
4. alcohol intake (i.e., alcoholics are oftentimes leaner though their calorie intakes are higher)
5. smoking (i.e., smokers are generally more lean than non-smokers)
6. variation of diet composition

In their own study of energy intake and relative weights, Romieu et al. (76) studied 141 females aged 34 to 59 and observed the same inverse relationship. However, the strength of this inverse correlation was reduced to essentially null when adjustments were made for age, activity, alcohol intake, and smoking. Importantly, however, they observed that obese women had a higher fat intake and a positive correlation ($r = .20$) between fat intake and body mass index (weight in kg/height in meters^2). Therefore, they concluded that fat

intake may be associated with obesity independent of total energy intake.

Dreon et al. (17) studied the relationship of body composition, as measured by underwater weighing, and nutrient intake, as measured by 7-day diet records, in 155 middle-aged, sedentary, free-living obese men. The nutritional analysis revealed diet composition as a percentage of calories to be typical for American males (37.5 ± 6.9% carbohydrate, 40.7 ± 5.7% fat, and 15.6 ± 2.6% protein, 6.2 ± 6.0% alcohol, and mean total calories 2570 kcal ± 514). The percent body fat and body mass index (BMI) were observed to have a significant positive correlation with intakes of total fat, saturated fat, and monounsaturated fats (grams/1000kcals ingested). On the other hand, a negative correlation was observed between percent body fat and total carbohydrate intake (grams/1000kcal ingested). Finally, no significant correlation was noted between total calorie intake and total weight, percent body fat, fat free mass, or body mass index.

In a study similar to Dreon et al., Miller et al. (60) studied the relationships among body fat, diet composition, energy intake, and exercise in 107 male adults and 109 female adults aged 18-71 years (mean = 36.6 years ± 1 year). Body composition was measured by underwater weighing. Subjects were instructed on how to estimate food portions in order to assess accurately food intake. Thereafter, intakes were measured over a total of 3 days using combined techniques for

assessing food intake, i.e. 24 hour food diary for two days, and a computerized program for food frequency determination. The data were analyzed for the group as a whole and also for the subjects divided by gender into lean and obese subgroups. Lean males had body fat $\leq$ 15% and obese males $\geq$ 25% body fat. Lean females had body fat $\leq$ 20% and obese females $\geq$ 35% body fat. The results were as follows:

1. Adiposity was positively correlated with dietary fat intake and negatively correlated with carbohydrate intake for both genders. This occurred despite the fact that energy intake was similar between obese and lean subjects of the same gender.
2. There was no relationship between adiposity and total energy intake when energy intake was expressed per kilogram of lean body mass.
3. In the aging male an increasing percentage of body fat was noted. This was not, however, correlated with increasing body weight nor with increasing fat intake. Conversely, the aging female also had an increasing percentage of body fat with increasing total body weight and with increasing fat intake.
4. Diets of obese females and obese males were the same, and diets of lean males and lean females were the same.

5. Lean subjects derived 53% of calories from carbohydrate and 29% of calories from fat. Obese subjects derived 46% of calories from carbohydrate and 35% of calories from fat.
6. Leanness and increased activity levels were positively correlated.

The authors concluded that diet composition in terms of increased fat intake may be as important as increased calories and lack of exercise in promoting fat deposition.

Berry et al. (6) studied 413 free-living, healthy American males and correlated body mass index, fatty acid composition of adipose tissue obtained by rapid needle aspiration, and a 30-day diet record for diet composition in a random sample of 220 of the subjects. Knowing that fatty acid composition of adipose tissue reflects the dietary composition of fatty acids, they found that obesity was weakly associated with animal fat and negatively correlated with vegetable oil (polyunsaturates). Also, importantly, they concluded that there was no relationship between obesity and carbohydrate intake, i.e., a high carbohydrate intake was not noted in the obese.

Tucker and Kano (95) studied the association between diet composition, especially in terms of fat content, and percent body fat in 205 adult females. They also studed the effects of multiple confounding factors on this association which included age, total energy intake, total exercise time per

week, number of years of exercise involvement, smoking, and consumption of other macronutrients. Subjects completed questionnaires and had skin fold thickness measured to determine percentage of body fat. Dietary fat intake was still significantly related to level of adiposity. Additionally, both protein and carbohydrate intakes had no predictive value of percentage of body fat after these confounding factors were controlled. These authors concluded that dietary fat intake may play a role in the etiology of obesity in addition to that of excessive caloric intake.

These studies, then, lend support to the concept that high fat diets are metabolically more efficient than high carbohydrate diets. Also, the association between high fat intake and obesity may be independent of calorie intake.

Animal Studies Regarding Diet Composition, Metabolic Efficiency and Obesity

It is now well established in animal studies that a high fat-low carbohydrate diet has a greater metabolic efficiency than a low fat-high carbohydrate diet. In this context, metabolic efficiency is expressed as a function of either (1) the ease with which obesity develops (i.e., expansion of body fat mass), (2) the total weight gain per unit of food ingested, or (3) the energy expended as measured by O_2 consumption or estimated heat loss.

Several animal studies involving several species and strains have well demonstrated the ease with which obesity occurs by giving a high fat-low carbohydrate diet (4, 8, 9,

11, 16, 18-21, 25-28, 33, 37, 38, 42, 47, 50, 52, 54, 55, 59, 61, 64, 66, 69, 77, 78, 80-85, 92, 93, 99). In fact, this has proven to be an effective and reliable method for producing an animal model for obesity (9, 20, 21, 33, 37, 42, 47, 59). The rate and amount of fat storage is approximately proportional to the percentage of fat content in the diet (18-21, 27, 54, 59, 66, 80, 81, 85, 99). Equally important in support of this concept associating high fat intake and obesity is the fact that obesity created by high fat intake is reversible when these obese animals are placed on the low fat-high carbohydrate regimen typical of animal lab chow (66, 80, 81). In this regard the animals assume the same weight level as if they had never become obese.

In terms of growth parameters and total weight gain, animals demonstrate greater growth on a high fat-low carbohydrate diet than on a high carbohydrate-low fat diet. However, this is due primarily to an expansion of the fat compartment (4, 16, 66, 80, 83). According to Donato and Hegsted (16) it appears that in rats there is essentially a direct conversion of dietary fat to body fat when diet composition is high in fat. Importantly, they also demonstrated a greater efficiency of a fat supplemented diet compared to a sucrose supplemented diet in terms of fat deposition even under conditions of a low level of supplementation of either of these substrates and of a low total energy intake. The total energy intake under these

conditions was such that it resulted in a significant growth limitation of the animals. They concluded appropriately that high fat diets preserve body fat more efficiently than high carbohydrate (sucrose) diets, and this phenomenon holds true under a wide spectrum of energy intakes including severely restricted total energy intake. Because of the above, they also concluded that equal energy intakes cannot be assumed to be equivalent physiologically because different energy sources have significantly different metabolic efficiencies. Finally, these data from Donato and Hegsted, as well as from other studies (26, 66, 81), demonstrate how changeable the fat compartment is compared to the lean compartment and how dramatically the fat compartment expands or contracts depending on the ratio of fat to carbohydrate in the diet (66, 80, 81).

It has been observed in several studies that efficiency of food utilization, which is measured in terms of a gain in body weight per grams of food ingested, is high with high fat-low carbohydrate consumption vs. high carbohydrate-low fat consumption (20, 21, 25, 26, 33, 52, 54, 61, 92). Interestingly, this efficiency is also seen in several studies where animals on a high fat-low carbohydrate diet gain more weight despite eating less grams of food (20, 21, 25, 26, 33, 52, 54, 61, 92). In one of these studies, Herberg et al. (33) observed in mice that a group of experimental animals on a high fat diet gained twice as much weight as the controls

while consuming slightly less total calories and eating less total grams of food per day as compared to the controls who were on a high carbohydrate intake. Though this observed increased efficiency of high fat diets in terms of weight gain per grams of food intake may be surprising, it is consistent with the known high calorie density of fat (9 kcal per gram) versus carbohydrate (4 kcal per gram) as well as the obligate energy expenditure difference associated with fat vs. carbohydrate metabolism as previously discussed (22). In addition, Herberg et al. (33) noted that fat cell hyperplasia in mice was significantly greater on the high fat diet. They concluded that the degree of obesity could not be predicted by the absolute calorie intake but was a direct reflection of diet composition.

Other studies have also given support to this lower efficiency of the high carbohydrate-low fat diet composition. As previously discussed, when obese rats on high fat diets were placed on lab chow, which is high in grains and low in fat, these animals lost weight. As discussed above, Herberg et al. (33) noted that the control animals (mice) took longer to gain even one-half as much weight while consuming a high carbohydrate-low fat diet as compared to the experimental group consuming a high fat-low carbohydrate diet. With this, the control animals actually consumed more total calories and more grams of food while consuming less grams of fat. Other studies have shown similar findings (54, 81, 84). Kanorek and

Hirsh (42) described an experiment to increase body weight by giving young rats ad lib access to a 32% sucrose solution in addition to lab chow. They observed that the experimental animals ingested 10-15% more calories per day than controls. However, the experimental animals still did not gain additional weight beyond the controls until they became 75 days old. Whereas the authors offered no definitive explanation, this may be an example of the relative metabolic inefficiency of the carbohydrate supplementation (sucrose) as the basis for this observation.

Metabolic efficiency of diet composition as reflected by energy expenditure has also been studied by measuring 02 consumption (8, 54) or estimated heat loss (25-28). Black et al. (8) measured a reduced 24 hour 02 consumption in rats consuming a 30% (by weight) fat diet as compared to rats consuming a 2% (by weight) fat diet. Lyon et al. (54) studied high carbohydrate-low fat versus high fat-low carbohydrate diet compositions in two different strains of mice (C_3H and C_{57}) and correlated weight gain and the thermogenic response in terms of oxygen consumption to each diet for each strain. Each strain showed a higher efficiency of food utilization (i.e., weight gain per grams of food eaten) on the high fat (50%) diet as compared to the low fat (5%) diet. Both strains consumed more calories on the high fat diet while eating less grams of food. The C_{57} strain had a higher oxygen consumption on the high fat diet and also a slower rate of weight gain

compared to the C_3H strain. The C_3H strain on high fat gained weight more rapidly but did not have an increased O_2 consumption as compared to mice of the same strain on low fat intake. In fact, the O_2 consumption on high fat for the C_3H strain decreased, but this was not significant statistically. Because O_2 consumption did not change significantly for C_3H on high fat, presumably these extra calories were deposited as fat rather than being dissipated as heat. This study, as well as others (84), also points out the significance of the interaction of genetic background and diet composition in obesity development. Forbes et al. (25-28) demonstrated that fat confers efficiency of utilization of food energy in terms of growth by decreasing overall heat production as the fat content in the diet is increased.

Though it is well recognized in animals that a tendency for obesity is a function of species, strain, and gender (20, 21, 42, 54, 77, 84, 85, 93) as well as age (42, 82, 83, 85) and individual variation (16, 80, 92), diet composition and especially the percentage of fat content in the diet may be the most important factor in the development of obesity in animals (33, 80, 81, 82).

Experimental Interventional Studies in Humans Regarding Diet Composition, Metabolic Efficiency, and Obesity

Several areas of human investigation in energy metabolism and diet composition merge to support the concept that high fat-low carbohydrate diets are more efficiently utilized than high carbohydrate-low fat diets. The areas emphasized include

(1) overfeeding of fat and/or carbohydrate, (2) issues of net de novo fat synthesis from carbohydrate, (3) substrate regulation and balance, and (4) change in diet composition with its metabolic correlates.

Over a period of approximately ten years, Sims and his colleagues (89, 91) at the University of Vermont studied experimental human obesity by inducing obesity in normal subjects through overeating. In their first phase of overeating experiments, volunteers were fed to tolerance up to 10,000 kcal per day for several months to achieve approximately a 25% increase in body weight. Four male volunteers on a mixed diet achieved approximately a 14 kilogram weight gain over seven months and required approximately 120,000 to 170,000 cumulative excess kcal per meter^2 over this period. In comparison, four different male volunteers on a high fat diet gained the same amount of weight in only three months and required only 30,000 to 60,000 cumulative excess kcal per meter^2. Furthermore, once the excess weight was achieved for both groups, the high fat group was able to maintain the elevated weight by continuing their high fat diet at a calorie intake that matched their previously established weight maintenance needs. On the other hand, the mixed diet group, while continuing their mixed diet, could only maintain their excess weight with an intake that exceeded their previously determined weight maintenance calorie needs (i.e., 2700 kcal per meter^2 after weight gain to

maintain excess weight compared to 1800 kcal per meter^2 for weight maintenance prior to weight gain). Thus, the data suggest that the high fat diet was metabolized more efficiently compared to the mixed diet, which was relatively higher in carbohydrate and lower in fat.

Several studies have looked at the issue of the ease with which net de novo fat synthesis from carbohydrate occurs in the human. Bjorntorp and Sjostrom (7) reported that there is a very limited capacity in the human, contrary to animal species including the rat, for conversion of carbohydrate to fatty acids and, hence, to fat storage. They estimate that in the non-obese person less than 1% of the carbohydrate intake actually is synthesized to fatty acids and stored as triglyceride. Pertinent to this lack of ease with which carbohydrate is stored as fat, which is also supported by Flatt (22), is the observation that the fatty acid composition of adipose tissue reflects primarily the content of the fatty acids present in the diet and not the de novo fatty acids synthesized (6, 7). It is also noted that carbohydrate storage preferentially is toward glycogen repletion (23) over de novo fatty acid synthesis and, as previously noted, is accomplished more efficiently (i.e., 7% of ingested kcal to store carbohydrate as glycogen as compared to 23% of ingested kcal to store carbohydrate as fat). Furthermore, Acheson et al. (1) have determined that the degree of glycogen repletion sets the stage for directing the

extent to which carbohydrate is stored as glycogen or as fat. For example, a high carbohydrate-low fat diet taken for 3 to 6 days will replete glycogen stores whereas a high fat-low carbohydrate diet taken similarly will deplete glycogen stores. They demonstrated that under the high carbohydrate antecedent diet condition a 500 gram carbohydrate load resulted in a greater net de novo lipogenesis over 24 hours than did the same carbohydrate load given under the high fat antecedent diet condition. However, even under the high carbohydrate condition with increased lipogenesis, the amount of fat synthesized was only nine grams over a 24-hour period, and this was associated with a concomitant 24-hour negative fat balance. This underscores the limited capacity of de novo lipogenesis even under high carbohydrate intake. These authors also observed that the thermogenic response to the test meal was greater under the high carbohydrate condition. Finally, in a series of experiments using indirect calorimetry, Passmore and Swindells (65) also could not demonstrate any significant de novo lipogenesis when normal subjects were overfed high carbohydrate meals over a several hour period.

It appears that there is a metabolic regulation of carbohydrate and protein intake to establish substrate balance but none for fat intake. Flatt et al. (24) studied serially the substrate oxidation rates of carbohydrate, protein, and fat of subjects who were given test meals containing fixed

carbohydrate and protein content but with varied fat content. The carbohydrate and protein oxidation rates directly reflected the carbohydrate and protein ingested and were not influenced by the presence of fat. On the other hand, the oxidation rate of fat was stable and was not influenced by fat content. That is, fat oxidation did not increase when fat content was increased. Thus, subjects were in a negative fat balance on a low fat intake and in a positive fat and energy balance as fat intake exceeded the endogenous oxidation rate of fat. These findings support the following:

(1) Fat balance is not metabolically regulated but directly reflects the amount of fat ingested in the diet.

(2) Short-term energy balance becomes a function of the amount of fat ingested in the diet.

(3) Fat intake which exceeds the endogenous fat oxidation rate is efficiently stored (i.e., fat efficiently goes to fat).

Several clinical studies have been done which have studied diet composition variously at different calorie intakes, with short term energy expenditure measurements, and with changes in weight in lean and/or obese subjects. Hurni et al. (36) studied 11 healthy, normal weight medical students (six females and five males) for seven days on a mixed (relatively low carbohydrate) diet followed by seven days on an isocaloric high carbohydrate-low fat diet. The mixed diet

had a mean food quotient (FQ) of 0.84 while the high carbohydrate-low fat diet had an FQ of 0.94. (Note that the FQ is the ratio of volume of CO_2 produced to the volume of O_2 consumed for combustion of energy intake and that the FQ for a typical mixed diet of 0.84 to 0.85 corresponds to an energy partition of approximately 45% carbohydrate, 40% fat, and 15% protein.) A fixed calorie intake of 1746 kcal was presented to each subject while subjects were allowed to take additional ad lib energy intake with foods consistent with the FQ for each respective experimental diet. A two-week interval on ad lib intake separated the two experimental diet periods. Energy expenditure was measured for 24 hours in a respiratory chamber at the end of each seven-day diet. The authors found no significant difference between the diets in the total 24-hour expenditure. However, they did observe that energy expenditure during sleep was higher on the high carbohydrate diet as compared to the mixed diet. For reasons not explained by the authors, all subjects were in a negative energy balance during both experimental diet periods. This in itself could result in a reduction of energy expenditure. The results associated with this study design raise the possibility that a longer period of exposure to the experimental diets, in addition to a longer period of assessment of energy expenditure, might have resulted in significant differences between the diets.

Lean and James (45) studied weight stable groups of lean, obese, and "post-obese" females for single 24-hour sedentary periods in a whole body respiratory chamber during a series of feeding conditions of fasting, high carbohydrate (82%) - low fat (3%), and high fat (40%) - low carbohydrate (45%) intakes, respectively. The diet compositions were isocaloric for each subject, and the number of calories presented to each subject was individualized according to their respective daily energy requirements. Energy expenditure expressed per kilogram of fat-free mass for each 24-hour period was not significantly different between diets or between groups. However, there was a tendency for the 24-hour energy expenditure per fat-free mass to be lower on the high fat diet as compared to the high carbohydrate diet for each group. Also, the thermogenic effect was significantly greater for the high carbohydrate diet as compared to the high fat diet. Finally, the sleeping energy expenditure was lower in the post-obese group on the high fat diet. The authors concluded that a longer exposure to the diet periods would be valuable and also expressed awareness that the extremes of substrate intakes were not physiologic and did not conform to levels of substrate intake in the general population.

Hendler et al. (32) studied the effect of changes in diet composition on resting metabolic rate in obese female subjects taking 800 kcal diets. After four days of weight maintenance intake (50% carbohydrate, 30% fat and 20% protein), six

subjects were given an experimental diet of 800 kcal composed of 1% carbohydrate, 4% fat, and 95% protein for 15 days followed by an isocaloric substitution of sucrose for the subsequent 15 days. The authors noted that the resting metabolic rate dropped, as did weight, for the first days but returned to baseline during the 15 days period on the sucrose diet despite continuing weight loss of the subjects. Also, four different subjects were placed on 800 calories of pure sucrose immediately after the weight maintenance diet and experienced weight loss without the expected decline in the resting metabolic rate. Though this study does not compare high fat with low fat intakes, it does demonstrate, at least in this population, that carbohydrate substrate enhances energy expenditure, which is an expression of dietary inefficiency.

Sheppard et al. (88) studied data in 303 women enrolled in the Women's Health Trial Feasibility Study which involved participation in a low fat dietary intake for over 2 years. Of these subjects 184 were randomized to the diet intervention group and 119 to the control group. The intervention group was actively involved in a comprehensive nutritional and behavioral educational program with regular organized follow up to enable subjects to lower fat intake from approximately 39% to 20% of energy intake. The control group was encouraged to maintain their current diet and received general health information only. Weight loss was not an emphasis of the

protocol. After one year the intervention group decreased fat intake by 45.3 grams (i.e., 39.2% to 21.6% of calories from fat) and lost 3.1 kg. The control group decreased fat intake by 8.3 grams (i.e., 38.9% to 37.3% of calories from fat) and lost 0.4 kg. The authors concluded that weight loss was more strongly related to the change in fat intake than with the change in total energy intake.

Taken together, the above epidemiologic, animal, and clinical studies lend strong support to the hypothesis that high fat-low carbohydrate diets are more efficiently metabolized than high carbohydrate-low fat diets and consequently promote obesity while retarding efforts for weight maintenance and weight reduction.

However, these studies do not and are not able to directly answer the question of whether these two diet compositions are inherently different metabolically with inherently different effects on energy expenditure in the human. The reasons for this include the following:

(1) Epidemiologic and animal studies by their nature cannot directly answer basic questions which are of an experimental nature pertinent to the human subject. Therefore, more clinical studies are needed of an experimental nature to address the question of inherent metabolic differences in diet composition in human subjects.

(2) Both animal and human studies have involved the use of unphysiologic levels (high and low) of energy intake and/or diet composition. Thus, under these conditions the differences metabolically in diet composition may be an expression of these unphysiologic presentations and may not otherwise truly express the inherent metabolic differences in diet composition at physiologic intake. Therefore, clinical studies are needed to explore the differences in diet composition when both energy and substrates are presented at physiologic levels.

(3) Few clinical studies have effectively studied physiologic diet compositions over prolonged periods. Exposures to the experimental diets and measurements of energy expenditure may have been too brief to bring out these metabolic differences in diet composition. For example, respiratory chamber measurements of energy expenditure are generally short term and exclude subjects from physiologic spontaneity which are otherwise present in the free-living condition. Therefore, studies are indicated which expose subjects to experimental diets for several weeks while in the free-living state.

(4) Obesity is acknowledged to be a heterogeneous state (90). Also, the presence or history of obesity implies a potential genetic difference between the

never-obese human subject and the obese subject. In effect, the obese subject may already be biased toward metabolic efficiency in heterogeneous ways which are not, at present, identifiable and, hence, not easily controllable in an experimental setting. Therefore, studies which use a potentially heterogeneous population of obese subjects to measure differences in diet composition may only have, at best, answers of approximation or may, at worst, obscure differences which are inherently present between the diets. On the other hand, a never-obese subject has demonstrated no bias toward obesity and, hence, may be metabolically more homogeneous and more appropriate experimentally for studying inherent metabolic differences in diet composition. Therefore, more studies are needed using never-obese subjects to explore the fundamental metabolic differences in diet composition.

(5) Finally, more studies are needed which control total energy intake while changes in diet composition are made. Several previous studies have not controlled the confound associated with altering diet composition which inherently alters calorie density and total calorie intake.

HYPOTHESIS AND OBJECTIVES

Hypothesis

A high carbohydrate-low fat (HC) diet generates a greater energy expenditure at weight maintenance calorie intake than an isocaloric, isonitrogenous intake of a high fat-low carbohydrate (HF) diet in healthy, never-obese, postmenopausal Caucasian female subjects.

Objectives

The objectives for this study were as follows:

1. to compare the resting metabolic rate (RMR) and changes in the six-hour postprandial metabolic response, i.e., diet-induced thermogenesis (DIT), between the HC diet and the HF diet after 22 days on each
2. to compare "within diet" and "between diet" differences in total body weight and in body composition (i.e., fat-free mass and fat mass) after 22 days each on the HC diet and the HF diet
3. to compare the differences in fasting and postprandial respiratory quotients (RQ) and substrate oxidations of carbohydrate, fat, and protein between the HC diet and the HF diet after 22 days on each
4. to compare differences in fasting glucose, insulin, glucagon, free fatty acids, cholesterol, triglycerides, T_4

and T_3, respectively, before and after 22 days on the HC diet and before and after 22 days on the HF diet.

5. to compare differences in fasting glucose, insulin, glucagon, free fatty acids, cholesterol, triglycerides, T_4, and T_3, respectively, between the HC diet and the HF diet after 22 days on each

6. to compare differences in the six-hour postprandial changes of glucose, insulin, glucagon, and free fatty acids, respectively, between the HC challenge test meal and the HF challenge test meal

METHODS

Subjects

Fourteen healthy, never-obese, postmenopausal, Caucasian females between the ages of 43 and 66 were recruited from the campuses of the University of Alabama at Birmingham and the Baptist Medical Centers and from the greater Birmingham area community. One subject withdrew from the study after the first week. Therefore, thirteen subjects completed the study. The characteristics of the thirteen subjects are shown in Table 1. The mean age was 56 ± 2 SEM years (range 43-66 years). The mean weight was 55.7 ± 1.4 kg (range 45.4 - 64.2 kg). The mean height was 161.4 ± 1.3 cm (range 154.3 - 171.4 cm). The body mass index (BMI) was 21.4 ± 0.6 (range 17.2 - 24.4). The percent body fat was 29.6 ± 1.7% (range 20.2 - 39.0%).

Postmenopausal subjects were selected to avoid confounders related to the increases that may occur in the 24 hour energy expenditure during the luteal (post ovulation) phase in menstruating females due to increases in progesterone (96). Additionally, since obese and post-obese individuals may be metabolically and genetically heterogenous with respect to energy expenditure relative to never-obese individuals, only never-obese individuals were selected. Historically, all

subjects had remained lifelong less than 120% of their reference weight for height using the 1959 Metropolitan Life Insurance Company Weight-Height Table as the reference standard. Other specific exclusion criteria included the following:

(1) the occurrence of a menstrual period within the previous twelve months

(2) current use of estrogen and/or progesterone replacements

(3) current history for smoking

(4) positive family history in first degree relatives for obesity as defined by a weight greater than or equal to 120% of the reference weight for height using the 1959 Metropolitan Life Insurance Company Weight-Height Table as the reference standard

(5) a personal or family history for diabetes mellitus

(6) any endocrine disorders

(7) current use of thyroid replacement

(8) current use of beta blockers

(9) any regular exercise program beyond brisk walking previous to or during the study

(10) the presence of allergies, intolerence, or aversions to any foods

Each subject underwent a complete medical history and physical examination by this investigator. The study was approved by the respective investigational review boards at the University

of Alabama at Birmingham and the Baptist Medical Centers, Birmingham, Alabama.

Experimental Design - Overview

Each of the 13 subjects was assigned to a randomized schedule to begin either the HC diet or the HF diet for 22 days and then cross over to the opposite diet for 22 days. Seven subjects started first on the HC diet while 6 subjects started first on the HF diet. Figure 1 presents the study design for this 9-week protocol. A period of diet stabilization for 7 - 10 days on a standard Western diet composition preceded entry into the first experimental diet period. A similar period of diet stabilization for seven days preceded the second experimental diet period. Subjects were allowed ad libitum intake for 6 days between the end of the first experimental diet period and the beginning of standard diet stabilization period prior to the second experimental diet period. Subjects were studied in groups of two. However, the last subject was studied by herself.

Composition of Experimental Diets

All diets were presented isocalorically at weight maintenance levels for each subject. Table 2 summarizes the compositions of the standard Western diet, HC diet, and HF diets, respectively. Table 3 shows the calorie intake distribution for carbohydrate, fat, and protein for each subject for the standard Western diet, HC diet, and HF diet, respectively. Table 4 shows the total caloric and protein

intake expressed per kg of total body weight for each subject. The standard Western diet composition consisted of 48% carbohydrates (30% complex and 18% simple), 38% fat, and 14% protein. The high carbohydrate-low fat diet consisted of 66% carbohydrates (30% complex and 36% simple), 20% fat, and 14% protein. The high fat-low carbohydrate diet consisted of 30% complex carbohydrates, 56% fat, and 14% protein. Since the simple carbohydrate content of the standard Western diet and the HC diet contained no significant fiber, the actual fiber content of these three diets was identical and was approximately 5 grams. Finally, because the ratio of polyunsaturated to saturated fatty acids (p/s ratio) influences diet-induced thermogenesis (DIT) but not resting metabolic rate (41, 58) the p/s ratio was 0.5 which is the p/s ratio of the standard North American diet (29).

Foods were selected from the typical Western diet and were prepared tastefully and invitingly by the General Clinical Research Center (GCRC) Research Kitchen, University Hospital, University of Alabama at Birmingham (UAB), under the direction of the research dietician. A series of 10 different menus were developed and rotated for each of the diet periods. The subjects frequently requested the recipes for selected meals which indicated a high degree of subject satisfaction with the menu selections. Calorie and nutrient content for all foods were derived from standard sources for food composition (2, 67, 94).

During the two weight stabilization periods food was picked up daily by the subjects and consumed away from the GCRC. During the two experimental diet periods food was picked up approximately twice weekly. Occasionally, subjects were away for several days for personal reasons and were given all of their food to take with them during these times. Intake compliance was monitored closely by the research dietician at least twice weekly. Each subject appeared to be conscientiously compliant with intake and did report to the research dietitian when food intake was incomplete. Patients did not keep intake records since all of their food was given to them from the GCRC Research Kitchen.

Determination of Energy Content for Weight Stablization

Prior to randomization each subject was followed and weighed daily for 7 - 10 days by the research dietician at the GCRC. The daily energy expenditure for weight maintenance for each subject was initially estimated using the Harris-Benedict equation (31) multiplied by 1.3 (71). Subjects were then given a diet of standard Western composition at their respective weight maintenance intakes. Weight stability at weight maintenance was achieved for each subject by small adjustments in daily calorie intake when necessary according to any daily weight changes. In actuality, this occurred infrequently. No more than 200 additional calories was ever needed to achieve weight stability for any subject during this period of weight stabilization. The final calorie intake

required to achieve weight maintenance stabilization for each subject became the number of calories for isocaloric presentation for all subsequent phases of this study, except for the six days ad libitum intake between the two experimental diet periods.

Data Collection and Procedures

Subjects were admitted overnight to the GCRC for 48 hours prior to beginning each experimental diet period and for 48 hours for the last 2 days of each experimental diet period to facilitate and standardize data collection. Subjects were required to be in the GCRC from the time of the evening meal until the following morning after data collection and breakfast were completed.

On the morning prior to the first day of each experimental diet period, subjects had body density determinations performed in the Department of Health and Physical Education at UAB to assess body composition using the technique of underwater weighing. Subjects were weighed in air using a beam balance scale and underwater using a Chatillon autopsy scale to determine fat mass (FM) and fat-free mass (FFM). Body density was determined by the ratio of body mass (kilograms) in air to body volume. The percent of body fat was determined by the following relationship (10):

$$\% \text{ body fat} = (4.570/\text{body density} - 4.142) \times 100$$

The FM was obtained by multiplying the percentage body fat by the total body weight in kilograms. The FFM was obtained by

subtracting FM from the total body weight in kilograms. This procedure was repeated on day 21 of each experimental diet period.

On the morning of the first day of each experimental diet period, fasting blood samples were obtained at 7 a.m. for glucose, insulin, glucagon, free fatty acids, cholesterol, triglycerides, and thyroid function studies. Blood samples were immediately centrifuged to obtain sera and plasma fractions and placed in ice. The plasma samples were transported on ice to the Department of Research at BMC Princeton Hospital for analysis of glucose, insulin, free fatty acids, cholesterol, and triglycerides. Glucose was measured by the glucose oxidase method. Insulin was measured by Radioimmunoassay [Corning Medical, Inc., Medfield, MA]. Free fatty acids were measured enzymatically [NEFA kit; Amano Internatinal Enzyme Co, Troy, VA]. Cholesterol and triglycerides were measured with the Encore Chemistry System, Serano-Baker, Allentown, PA. The serum samples were sent to UAB clinical laboratories for analysis of T_4 and T_3. The procedure was repeated on day 21 of each experimental diet period for thyroid studies and on day 22 for glucose, insulin, glucagon, free fatty acids, cholesterol, and triglycerides.

On day 22 of each experimental diet period, subjects were awakened at 6 a.m. and prepared to leave the GCRC for a 10 minute drive to the Department of Research at BMC Princeton Hospital to undergo indirect calorimetry (39, 40) to measure

resting metabolic rate (RMR) and diet-induced thermogenesis (DIT), i.e., the thermic effect of a liquid test meal.

With indirect calorimetry the amount of CO_2 produced and the amount of O_2 consumed by a subject were measured and converted to an equivalent amount of energy expenditure in kilocalories (98). This ratio of carbon dioxide produced to O_2 consumed is the respiratory quotient (RQ). Knowledge of the RQ and a 24-hour urine for urea nitrogen allowed for determinations of relative substrate oxidation of carbohydrate, fat, and protein comparatively under the conditions of HC and HF diets, respectively (53).

The measurement of carbon dioxide production and oxygen consumption was determined by the Continuous Respiratory Gas Analyzer (CRGA) described by Kinney et al. (44) in 1964 and modified by Long et al. (51) in 1979. The CRGA communicated with a large transparent head canopy made of lucite which was comfortably placed over the subject's head while the subject was resting comfortably in the supine position with head slightly elevated. A flexible seal was made at the neck with velcro to produce a closed, air-tight system. Balanced ventilation was maintained by a continuous flow of room air from a remote source to the canopy which was then continuously withdrawn from the canopy into the CRGA for determination of carbon dioxide and oxygen concentrations. The design of the canopy permitted the subject to be completely observed at all times without hindrance. Also, the subject was able to

observe the surroundings without hindrance and able to watch television if desired. The canopy was easily removable to allow easy entry and exit.

Upon arrival to BMC Princeton Hospital, subjects were taken to the study room in the Department of Research and were comfortably placed in the supine position. Because of a limitation in time availability for use of the calorimeter, subjects were studied in pairs except for the last subject. Intravenous access was then achieved with an 18-gauge catheter placed near the antecubital fossa to allow for serial blood samples to be obtained through a heparinized lock. Subjects were then placed into the canopy for 30 - 40 minutes to determine the RMR. Measurements of energy expenditure were recorded each minute. The last 10 - 15 minutes of measurements were averaged and used as the RMR value. One of the subjects then drank over 2 - 3 minutes a liquid test meal prepared by the GCRC Research Kitchen containing the same diet composition as the respective experimental diet at 14.3 kcal/kg FFM. This subject was then immediately placed into the canopy for 40 minutes for DIT measurements while the other subject rested in a supine position. After the 40 minute period was completed, the canopy was removed and then placed comfortably over the other subject's head for a 40 minute period of DIT measurements. This sequence was repeated, i.e., 40 minutes of DIT recording followed by 40 minutes outside the canopy, until each subject had five 40 minute DIT measurement

periods over 360 consecutive minutes (6 hours). The DIT values were most stable and, therefore, averaged from minutes 10 - 35 for each 40 minute DIT period. Subjects were allowed to watch television programs of their choice while in the canopy but were not permitted to fall asleep. They were also permitted to read or use the restroom while outside the canopy but otherwise stayed in bed. Blood was drawn at the end of each of the five 40 minute DIT periods for glucose, insulin, glucagon, and free fatty acids and processed as before. A 24-hour urine collection for urea nitrogen was started at noon on day 22 and finished at noon on the following day.

Statistical Method

CLINFO was used for data organization through the GCRC. Because the present study used a crossover design to compare subject response to two different dietary exposures, i.e., HC vs. HF, the paired comparisons test (14) was used as the statistical strategy to assess mean differences between each given variable of interest under these two conditions. A one-tailed t-test was used since the hypothesis states that metabolic changes and energy expenditures will be greater under HC conditions. Note that all data were not available for all subjects for all assessments.

RESULTS

Body Composition

Tables 1-6 (Appendix) show the mean differences in total body weight, fat-free mass, and fat mass for the 13 subjects after 22 days each of the HC and HF diets. These data are summarized in Table 5. There is a significant mean total body weight loss of 0.47 kg for subjects after the HC diet ($p < .025$) but no significant total body weight change for subjects after the HF diet. Furthermore, there was a nonsignificant trend toward reduction in the fat-free mass ($p = .08$) after the HC diet. There was no significant change in either the fat-free mass ($p > .10$) or the fat mass ($p > .10$) after the HF diet. Furthermore, there were no significant differences between the HC diet and the HF diet in the relative changes in total body weight ($p = .08$, Table 7 Appendix), fat free mass ($p > .10$, Table 8 Appendix), and fat mass ($p > .10$, Table 9 Appendix).

Resting Energy Expenditure

Table 10 (Appendix) shows a higher mean resting metabolic rate (RMR) of 49 kcal/24 hours after 22 days on the HF diet compared to 22 days on the HC diet. Seven of the 12 subjects had higher RMR values on HF. The data from subject number 6 were not available because of technical problems associated

with the data collection. Since this finding is contrary to the hypothesis that RMR is greater after the HC diet compared to the HF, the null hypothesis cannot be rejected, and the statistical conclusion is that the RMR is not greater after the HC diet compared to the HF diet.

Diet-Induced Thermogenesis

The differences in diet-induced thermogenesis (DIT) between the HC diet and the HF diet are shown by Tables 11-28 (Appendix) and displayed by Figures 2-5 (Appendix). Tables 11-15 (Appendix) show a nonsignificant trend for DIT expressed in absolute kilocalories expended to be greater after the HC challenge test meal compared to the HF challenge test meal for each of the five time periods. The mean differences were as follows: -0.50 ± 0.32 kcal between 1-40 minutes (P = .075), -1.35 ± 0.98 kcal between 81-120 minutes (P = .10), -1.08 ± 0.83 kcal between 161-200 minutes (P=.12), -0.26 ± 0.26 kcal between 241-280 minutes (p=.18), and -0.37 ± 0.24 kcal between 321-360 minutes (p=.08). These data are displayed by Figure 2 and summarized in Table 6.

Tables 16-19 (Appendix) express the same data as differences in cumulative energy expenditure as DIT between the HC and HF challenge test meals from 1 - 120 minutes (through Period 2), 1 - 200 minutes (through Period 3), 1 - 280 minutes (through Period 4), and 1 - 360 minutes (through Period 5). Since energy expenditure was not measured postprandially 41 - 80 minutes, 121-160 minutes, 201 - 240

minutes, and 281 - 320 minutes, all cumulative energy expenditure data throughout were obtained by extrapolation of the measured energy expenditure data between each unmeasured period from 1 - 360 minutes. There was a nonsignificant trend also for DIT expressed in this way to be greater after the HC challenge test meal versus the HF challenge test meal for each of four cumulative test periods. The mean differences for each of these respective periods were as follows: -2.9898 ± 2.0415 kcal (P = .09), -5.3641 ± 3.8021 kcal (P = .10), -6.3185 ± 4.3407 kcal (P = .09), and -6.8281 ± 4.5474 kcal (P = .08). These data are displayed in Figure 3 and summarized in Table 7. The net increase in DIT was 6.8 kcal/360 minutes after the HC challenge.

Tables 20-23 (Appendix) express the data similarly as cumulative energy expenditure as kilocalories per kg fat-free mass. There was again a nonsignificant trend for the DIT/FFM to be greater after the HC challenge test meal for each of four cumulative test periods. These mean differences were as follows: -0.0721 ± .0516 kcal/FFM (P = .10), -0.1269 ± .0957 kcal/FFM (P = .11), -0.1475 ± .1076 kcal/FFM (P = .10), and -0.1587 ± .1118 kcal/FFM (P = .09). These data are displayed by Figure 4 and summarized in Table 8.

Finally, the same data are shown in a similar way in Tables 24-28 (Appendix) and Figure 5 expressed as cumulative energy expenditure in kcal as a percentage of ingested kilocalories. A nonsignificant trend for DIT/percentage of

ingested kilocalories to be greater after the HC challenge test meal compared to the HF challenge test meal was again seen for each of five cumulative test periods. The mean differences expressed as kcal/percentage of ingested calories were as follows: -.0009 ± .0006 ($p = .08$), -0.0050 ± .0036 ($p = .10$), -0.0089 ± .0067 ($p = .11$), -0.0103 ± .0075 ($p = .10$), and -0.0111 ± .0078 ($p = .09$). These data are summarized in Table 9.

Respiratory Quotient

Table 29 (Appendix) shows the statistically significant higher total respiratory quotient or RQ (mean difference = -0.06 ± .03, $p < .025$) in the fasting state after 22 days on the HC diet as compared to the fasting state after 22 days on the HF diet. Also, Tables 30-34 (Appendix) show the statistically significant higher RQ values after the HC challenge test meals compared to the HF challenge test meals for each of the five DIT measurement periods. The mean differences were as follows: -0.07 ± .03 between 1-40 minutes ($p < .025$), -0.12 ± .04 between 81-120 minutes ($p < .01$), -0.18 ± .06 between 161-200 minutes ($p < .01$), -0.18 ± .05 between 241 - 280 minutes ($p < .005$), and -0.07 ± .03 between 321 - 360 minutes ($p < .025$). Figure 6 displays all of these above differences and are summarized in Table 10.

Substrate Oxidation

As predicted by the RQ data, Table 35 (Appendix) shows that carbohydrate oxidation under fasting conditions was

significantly greater after 22 days on the HC diet compared to 22 days on the HF diet (mean difference = -55.75 ± 26.60 grams, $p < .05$). Similarly, Tables 36-40 (Appendix) show that carbohydrate oxidation was significantly greater in the five DIT measurement periods over six hours after the HC challenge test meal compared to the HF challenge test meal. The mean differences expressed in grams for the respective time periods were as follows: -64.34 ± 28.42 ($< .025$), -141.19 ± 40.20 ($p < .005$), -49.49 ± 19.46 ($p < .025$), -51.28 ± 22.7 ($p < .025$), and -111.67 ± 31.80 ($p < .005$). The data are summarized in Table 11.

Table 41 (Appendix) shows that fat oxidation under fasting conditions was significantly greater after 22 days on the HF diet compared to 22 days on the HC diet (mean difference = 25.78 ± 11.77 grams, $p < .05$). Similarly, Tables 42-46 (Appendix) show that fat oxidation was significantly greater in the five DIT measurement periods over six hours after the HF challenge test meal compared to the HC challenge test meal. The mean differences expressed in grams for the respective time periods were as follows: 32.46 ± 14.37 ($p < .025$), 45.15 ± 16.30 ($p < .01$), 63.21 ± 20.53 ($p < .01$), 63.54 ± 16.99 ($p < .005$), and 24.41 ± 11.77 ($p < .05$). These data are summarized in Table 47 (Appendix).

Table 48 (Appendix) shows that the mean protein oxidation was significantly greater after 22 days on the HF diet compared to 22 days on the HC diet and occurred in 9 out of 12

subjects (mean difference = 8.63 ± 2.9 grams, $p < .01$). Table 49 (Appendix) shows that protein balance was significantly less when measured after 22 days after the HF diet compared to 22 days on the HC diet in the 12 subjects analyzed (mean difference = -8.5 ± 2.9 grams, $p < .01$). Protein balance was negative in 8 of 12 subjects after 22 days on the HF diet.

Substrate and Hormone Responses

Differences in concentration of measured substrates and hormones were compared at various times as follows:

1) fasting levels before and after 22 days each on the HC and HF diets, respectively (i.e., within diet comparisons)
2) fasting levels between the HC and HF diets after 22 days each (i.e., between diet comparisons)
3) postprandial levels between the HC and HF diets at each of the five postprandial measurement periods

Tables 50-65 (Appendix) show the differences in fasting levels for glucose, insulin, glucagon, free fatty acids, total cholesterol, triglycerides, T_4, and T_3 before and after 22 days on either the HC or HF diet, respectively. These differences are summarized in Table 12. Glucose levels rose significantly on the HF diet ($p < .025$) in 11 out of 12 cases. Glucagon levels fell significantly on the HC diet ($p < .05$). Free fatty acid levels rose significantly on the HC diet ($p < .01$). A nonsignificant trend was noted for the triglyceride levels to fall on the HC diet ($p = .09$), but triglyceride levels fell

significantly on the HF diet ($p < .05$). No significant differences were otherwise observed.

Tables 66-73 (Appendix) show the respective differences in fasting levels for glucose, insulin, glucagon, free fatty acids, total cholesterol, triglycerides, T_4, and T_3 between the HC diet and the HF diet after 22 days on each. These differences are summarized in Table 13. Triglyceride levels were significantly lower after the HF vs HC diet ($p < .05$). No significant differences were otherwise observed.

Tables 74-78 (Appendix) and Figure 7 show the differences in the change in glucose concentration between the HC diet and the HF diet after a challenge test meal for each of the five postprandial measurement periods. Tables 75 and 76 (Appendix) show a significantly greater change in glucose concentration during period 1 (1 - 40 minutes, $p = .004$) and period 2 (81 - 120 minutes, $p = .01$), respectively, after the HC challenge test meal compared to the HF challenge test meal. There were no significant differences observed for the three remaining postprandial measurement periods, i.e., $p = .19$, .28, and .33, respectively.

Tables 79-83 (Appendix) and Figure 8 show the differences in the change in insulin concentration between the HC diet and the HF diet for the five postprandial measurement periods. Tables 80 and 82 (Appendix) show a significantly greater change in insulin concentration during period 2 (81 - 120 minutes, $p < .0001$) and period 4 (241 - 280 minutes, $p = .04$),

respectively, after the HC challenge test meal. Table 81 (Appendix) shows a nonsignificant trend ($p = .07$) for insulin concentration to be greater after the HC challenge test meal during period 3 (161-200 minutes). Table 79 (Appendix) shows no significant difference ($p = .13$) during period 1 (1 - 40 minutes). Table 83 (Appendix) shows that the insulin concentration was not greater after the HC challenge test meal during period 5 (321 - 360 minutes).

Tables 84-88 (Appendix) and Figure 9 show the differences in the change in glucagon concentration between the HC diet and the HF diet for the five postprandial measurement periods. No significant differences were seen for any of the five postprandial periods.

Finally, Tables 89-93 (Appendix) and Figure 10 show the differences in the change in free fatty acid concentrations between the HC diet and the HF diet for the five postprandial measurement periods. Tables 89 and 90 (Appendix) show no significant differences during period 1 (1 - 40 minutes, $p = .11$) or during period 2 (81 - 120 minutes, $p = .22$), respectively. However, Tables 91-93 (Appendix) show a significantly greater change (i.e., in this case representing a reduction) in free fatty acid concentration during period 3 (161 - 200 minutes, $p = .006$), period 4 (241 - 280 minutes, $p = .003$), and period 5 (321 - 360 minutes, $p = .01$) respectively, after the HC challenge test meal compared to the HF challenge test meal.

DISCUSSION

The present study investigated the effects of physiological changes in diet composition after 22 days each of a HC vs a HF diet on changes in RMR, DIT, RQ, substrate oxidation, and biochemical parameters including glucose, insulin, glucagon, free fatty acids, cholesterol, triglycerides, T_4 and T_3. The intent was to study the effects of these changes while keeping diet composition within a physiologic range approximating the upper and lower extent of carbohydrate and fat intakes within Western Society. In this way findings become transferable directly to conditions of daily living. Furthermore, a homogeneous group of subjects was selected for study consisting of healthy, never-obese, postmenopausal, Caucasian females. The present study differed from most previous studies on diet composition which have generally looked at pharmacologic rather than physiologic intakes(solid foods and liquids) of carbohydrate and fat in mixed populations (obese and lean, male and premenopausal females, generally younger adults, and mixed ethnicity) for brief time periods.

Weight Change and Body Composition

A major finding of the present study was that subjects lost weight after 22 days on the HC diet (mean = 0.47 kg, $p <$

.025) but had no significant change in weight after 22 days on the HF diet ($p > .10$). No attempt was made to maintain weight stability after the first experimental diet was initiated. Additionally, there were no significant differences between the diets in fat-free mass or fat mass. However, there was a nonsignificant trend ($p = .08$) for fat-free mass to be reduced after the HC diet. Therefore, in the present study underwater weighing did not identify the changes in body composition that should have accompanied a mean weight loss of 0.47 kg after 22 days on the HC diet.

Others have found either no change in body composition or a loss in fat mass with a gain in fat-free mass after several weeks on a low fat diet. Prewitt et al. (72) demonstrated a loss of fat mass and a gain in fat-free mass after 20 weeks on a 20% fat diet. Conway et al. (12) demonstrated a loss of fat mass and no change in total body weight on 20% fat intake for 4 months. Hill et al. (35) speculated a loss in fat compartment over time if individuals should be placed on low fat diets. On the other hand Roust et al. (79) demonstrated no change in body weight or body composition after 4 weeks of a 27% fat diet.

The finding of weight loss on the HC diet but no weight change on the HF diet suggests that there is either an increase in energy expenditure relative to energy intake on the HC diet or that the HC diet is indeed more energy inefficient compared to the HF diet at isocaloric intakes.

The Vermont studies on experimental obesity in humans have suggested the presence of a relative inefficiency of the HC diet compared to the HF diet at excessive calorie intakes over several months (89, 91). Others have also supported the concept of HC diet inefficiency relative to the HF diet (13, 90).

Bandini et al. (3) recently studied the effects of a high carbohydrate diet (HC) at 83.1 ± 3.7% of total calories with those of a high fat diet (HF) at 83.5 ± 3.6% of total calories isocalorically and isonitrogenously in 7 young adults for 9 - 21 days. The RMR was not different between the two diets. However, in 5 of the subjects TEE (total energy expenditure), as measured by the doubly labeled water method, was higher on the HC diet. In addition, activity levels were estimated from the ratio of TEE/RMR. A nonsignificant trend ($p < .06$) for an increased TEE/RMR was observed on the HC diet. They reported that their subjects felt lethargy and even nausea initially during the HF diet. Because of this they postulated that the HF diet may actually reduce activity levels and predispose to obesity over a long period of time. Furthermore, these authors noted that subjects on the excessive HF diet tended to lose weight but felt that this was due to glycogen and water stores being mobilized analogous to what is seen in the early phase of a protein-modified fast. The results of this study suggest that an isocaloric change in diet composition is more closely associated with an increase in TEE (possibly through

increased activity) than with a metabolic inefficiency from high carbohydrate intake.

Prewitt et al. (72) studied 18 racially mixed premenopausal obese and non-obese females for 4 weeks on a 37% fat diet followed by a 20% fat diet for 20 weeks. The BMI range was 18 - 44. Overall, there was a decrease of 2.9% of body weight for the group after the 20% fat diet. Body fat decreased by 11.3% with a gain of lean mass of 1.6 kg for the obese group only. This occurred despite attempts to keep weight stable by increasing energy intake while subjects were on the lower fat intake. Total energy intake was 119% greater on the low fat diet compared to the HF intake. The results of this study suggest the presence of a metabolic inefficiency of the low fat-higher carbohyrate intake and/or an increase in activity levels since subjects had increased calorie intake on this diet and still lost weight. Components of daily energy expenditure were not measured.

Conway et al. (12) studied 38 premenopausal females held at constant weight on 40% fat for 4 months followed by a 20% fat diet for 4 months. The subjects were noted to have significant loss of fat as assessed by anthropometric measures after the 20% fat diet. These results do not identify the mechanism associated with loss of body fat on a low fat diet, i.e., increased energy expenditure vs. metabolic inefficiencies related to changes in diet composition.

Leibel et al. (46) were unable to find any difference in total energy intake needed to maintain body weight in a retrospective study of 16 subjects given liquid diets of widely differing fat-carbohydrate ratio for 15 - 56 days on a metabolic ward. Fat content varied from 0 - 70% of total calories. Subjects were not free living and had activity curtailed. Also, body composition studies were not done. These results did not indicate any differences in metabolic effiencies in liquid diet intake over a wide range of fat to carbohydrate ratios. Components of daily energy expenditure were not measured.

These studies suggest that changes in diet composition may be associated with changes in TEE, i.e., such as with associated increases in activity levels, and/or with differences in metabolic efficiences depending on the extremes of diet composition changes and the conditions of intake.

What are the possible mechanisms in the present study causing subjects to lose an average of 0.47 kg total body weight after 22 days on the HC diet but have no weight change after the HF diet? (This translates into approximately 3290 kcal deficit if it is assumed a deficiency of 7.0 kcal/gram of adipose tissue and that the weight loss was totally adipose tissue. This amounts to an average 149.5 kcal deficit daily for 22 days.) Assuming the absence of malabsorption, weight loss implies that subjects (1) increased energy expenditure, (2) decreased energy intake and/or (3) consumed a diet

composition which was less efficient in terms of maintinaing body weight at isocaloric intakes.

In the present study RMR was not significantly higher after 22 days on the HC diet compared to 22 days on the HF diet. Consequently, the HC diet does not increase energy expenditure through an increase in RMR. This is supported by others (3, 34, 35).

The DIT showed a nonsignificant trend to be higher after the HC challenge test meal compared to the HF challenge test meal. However, this amounted to an average of 6.8 kcal over six hours in terms of absolute energy expended or approximately 20.4 kcal per three 6-hour DIT periods in 24 hours. Thus, the DIT may contribute to an increased daily energy expenditure on the HC diet but does not account for the majority of the energy expended for the magnitude of this weight loss.

Total daily energy expenditure (TEE) was not measured in the present study. Subjects were asked not to deviate from their usual activity patterns. Bandini et al. (3) determined an increase in total energy expenditure for subjects taking a HC diet compared to the HF diet and attributed this to a possible increase in overall activity levels as estimated by the ratio of TEE/RMR. In the present study it is distinctly feasible that subjects could have increased their activity levels modestly to the average daily level of 149.5 kcal while taking the HC diet compared to the HF diet to account for

their weight loss. Bandini et al. (3) postulated that subjects may become relatively less active on an 83.5% - HF diet related to a diminished sense of well being from the HF diet, i.e., nausea, lethargy, and symptoms relating to a decrease in gastric emptying from the increased fat intake. During their follow-up sessions, the subjects in the present study frequently, though informally, reported an increased sense of well being while on the HC diet compared to the HF diet.

Though it is possible that subjects were less compliant with intake while on the HC diet to cause their weight loss, this seems unlikely. They were seen no less than twice weekly and often times more frequently. During follow ups they were specifically assessed for complaints and/or problems with the diets, and few were reported. The overall behavior of these subjects led us to believe that compliance was satisfactory.

Thus, the mechanisms which contribute to weight loss after the HC diet in this study are not specifically defined from the results but are inferred. RMR does not increase TEE. DIT contributes potentially only a small percentage, at best, towards an increase in TEE. Therefore, the mechanisms for weight loss may be the presence of an increase in TEE from an increased activity while on the HC diet and/or the differences in metabolic efficiences which favor weight loss on low fat intakes of not greater than 20%.

Resting Metabolic Rate (RMR) and Diet-Induced Thermogenesis DIT)

The resting metabolic rate was not higher after 22 days on the HC diet compared to 22 days on the HF diet. It is known that the RMR accounts for 60-75% of total daily energy expenditure (13, 90) and that the extent of the fat-free mass is the primary determinant of the resting energy expenditure (34, 63). Also, the fat mass is a lesser determinant of resting energy expenditure (34, 63). As discussed, the present study was not able to measure any significant change in fat-free mass or in fat mass.

Bandini et al. (3) did not find any difference in RMR at extreme intakes of their HC and HF diets, but their diet exposure times were shorter i.e., 9 - 21 days. Also, body composition was not measured. Hill et al. (35) measured 24-hour energy expenditures in eight subjects after 3 days and after 7 days while on a 60% carbohydrate-20% fat diet and repeated these measures in crossover design while subjects were on a 60% fat - 20% carbohydrate diet. The RMR did not differ during this study. Differences in RMR, perhaps reflecting differences in body composition, may have occurred if all subjects in both studies had been exposed to longer periods of their respective experimental diets. The studies by Prewitt et al. (72) and Conway et al. (12) did not report RMR measures. Other investigators also support the conclusion that RMR is not directly influenced by diet composition (30, 70, 73).

The DIT measured over a 6-hour period demonstrated a nonsignificant trend to be greater after the HC challenge test meal compared to the HF challenge test meal. The 6-hour DIT period was subdivided into 5 periods of forty minutes each. This trend for DIT to be greater after the HC challenge existed across the 5 measurement periods whether the DIT was expressed in absolute kilocalories, cumulative kilocalories, cumulative kilocalories per kilogram of fat-free mass, or cumulative kilocalories as a percentage of ingested kilocalories.

The DIT has been studied extensively and is known to be influenced by numerous factors as reviewed by Kinabo and Durnin (43). One of the most important of these is antecedent diet. Acheson et al. (1) demonstrated in 16 healthy young males that the DIT response to a 500 gram carbohydrate oral challenge was greater after subjects were on a high carbohydrate intake for 6 days and lesser when subjects were on a high fat diet for 3 days before the carbohydrate challenge. Kinabo and Durnin (43) studied DIT at two levels of energy intake (600 kcal vs 1200 kcal) in 16 adult, non-obese, premenopausal females and concluded that DIT is affected significantly by the energy intake of the challenge meal rather than diet composition per se. Antecedent diet composition was not controlled. However, there is other support in the literature both favoring (15, 87, 100) and denying (5, 68) the role of diet composition on enhancing DIT.

Finally, Nelson et al. (62) have demonstrated a blunted DIT in obese, postmenopausal females which was not improved with weight loss, thus showing that the DIT response to a given diet composition may be influenced by the genetic background of the subject.

RQ and Substrate Oxidation of Carbohydrate, Fat and Protein

The fasting RQ values were significantly higher ($p < .025$) after 22 days on the HC diet compared to 22 days after the HF diet. Furthermore, the RQ values remained consistently higher throughout the 6-hour DIT measures after the HC challenge test meal as compared to the HF challenge test meal. Accordingly, carbohydrate oxidation was greater under HC vs HF conditions. Also, fat oxidation was greater under HF vs HC conditions. This demonstrates that the composition of the diet (i.e., HC vs HF with a high FQ and a low FQ, respectively), determines the subsequent patterns of substrate oxidation in the fasting state and in the postprandial state. That is, the RQ response to diet compositiontends to approach the FQ of the diet. The findings of Hill et al. (35) are similar.

The time frame for substrate oxidation changes to occur as a reflection of changes in diet composition is not immediate and apparently not the same for carbohydrate compared to fat. Flatt et al. (24) studied in 7 young non-obese males the effect of adding supplemental fat on postprandial substrate oxidation for 9-hours and noted no

change in postprandial RQ. Schutz et al. (86) extended this study in a similar study group where each member spent 72 hours in a respiratory chamber and consumed a high fat supplement (106 ± 6 g of fat) after the first 24 hours. The fat supplement did not change 24 hour energy expenditure and did not change the fat oxidation rate. That is, the additional energy taken in as fat was transported into the fat compartment and not oxidized. Hill et al. (35) demonstrated in a group of 8 moderately obese young adults that a change in diet composition can produce a significant change in carbohydrate and fat oxidation between 3 and 7 days and without any measurable change in total energy expenditure. As in the present study, they observed that carbohydrate oxidation was higher on the HC diet and lower on the HF diet and vice versa for fat oxidation.

Protein oxidation was significantly higher in the present study after 22 days on the HF diet as compared to 22 days on the HC diet ($p < .01$). Hill et al. (35) reported no difference in protein oxidation after 7 days each of a HC or a HF diet, respectively. Bandini et al. (3), Prewitt et al. (72), and Conway et al. (12) did not report information on protein oxidation. Taken together these findings suggest that there may be at least a one-week delay before a shift in protein oxidation occurs after a change in diet composition occurs with respect to carbohydrate and fat content. These findings also demonstrate a protein-sparing effect after the

HC diet. Furthermore, protein balance was significantly more positive on the HC diet compared to the HF diet ($p < .01$) after 22 days. In fact, all subjects were in positive protein balance under HC conditions while 5 of 12 subjects were in a negative protein balance under HF conditions. This occurred at an average calorie intake for both diets at 28.6 kcal/kg body weight per day and an average protein intake of one gram/kg body weight per day. Since carbohydrate oxidation was lower under the HF diet, the body may have been responding to a relative carbohydrate deficiency by promoting gluconeogenesis mechanisms, i.e., increasing protein oxidation, to compensate. Interestingly, McCargar et al. (57) noted a nonsignificant trend for cortisol to be increased under HF conditions in their clinical study after 14 days. This favors the process of gluconeogenesis and results in an increase in protein oxidation.

Richardson et al. (74) reported similar trends in 10 healthy non-obese young men where isocaloric substitution of dietary fat for carbohydrate was done at a mean intake of 45 kcal/kg body weight per day and at 0.57 gram of protein/kg body weight per day. The HC diet was approximately 60% carbohydrate and 32% fat for 21 days while the HF diet was approximately 47% carbohydrate at 47% fat for 21 days. Both protein balance and utilization were significantly improved under the HC condition.

On the other hand, McCargar et al. (57) reported a nitrogen sparing effect of a high fat diet in 6 healthy, non-obese young male university students. Subjects were studied for 14 days each on 4 diet treatments, i.e., two levels of energy intake each of a HC and HF diet. The energy levels were approximately 50 kcal/kg body weight per day and 37 kcal/kg body weight per day, respectively. Subjects gained weight irrespective of diet composition on the higher energy intake and lost weight on the lower energy intake with a greater loss occurring on the HC composition compared to the HF composition. A positive nitrogen balance was seen only at the higher level of energy intake. The study of McCargan et al. differed from the present study by several factors including number of subjects, duration, antecedent diet stabilization, and levels of total energy and protein ingested. Furthermore, McCargar et al. (56) reported similar results in a study with adult male Sprague-Dawley rats divided into 6 groups of 6 each fed 10 weeks isocalorically and isonitrogenously but differing in the carbohydrate-to-fat ratio from 0.5 (highest fat) to 3.0 (highest carbohydrate). The results of both studies merit further inspection and verification by others.

Substrate and Hormone Changes

In general there was stability in substrate and hormone levels before and after the HC diet, before and after the HF diet, and between the HC and the HF diets after 22 days.

These findings are in agreement with other investigators (57, 74). The finding of a decrease in fasting glucagon after the HC diet was expected, but the increase in fasting levels of free fatty acids was unexpected after 22 days on the HC diet. Since subjects did lose weight while on the HC diet, the increase in free fatty acids might represent a response to a slightly hypocaloric state relatively or to a state of overall increased activity (34) associated with a high carbohydrate diet as suggested by Bandini et al. (3). Triglycerides are known to be lower on a HF diet (57, 74) at least on a short term basis. The T_3 is known to be directly correlated with changes in calorie intake as well as with changes in carbohydrate intake (3, 13, 57, 70). There were no changes seen in T_4 or T_3 throughout the present study. Changes in T_3 observed by others (3, 13, 57) were seen when comparisons in diet composition occurred at higher caloric intakes than were given in the present study.

The postprandial substrate and hormone responses to the challenge test meals were generally in agreement with the observations of others (62). Glucose and insulin increased significantly and free fatty acids decreased significantly after the HC challenge.

In conclusion, the present study does show that diet composition at normal physiologic intakes in healthy, never-obese, postmenopausal, Caucasian females inherently and directly influences substrate oxidation rates of carbohydrate,

fat, and protein and alters total body weight. Furthermore, since subjects lost weight on the HC diet, the study suggests that from a thermodynamic standpoint a relationship may exist between diet composition and TEE, possibly mediated through altered patterns of physical activity and/or factors relating to the potential metabolic inefficiencies of the HC diet including potential for a negative fat balance on the HC diet. A negative fat balance over time could result in body energy loss, total body weight change, and a change in body composition (35). These findings confirm the results of earlier studies on diet composition but extend these to a population of middle-aged females which has not previously been studied and at diet compositions that are physiologic and that are likely to be consumed by free living persons.

The data on protein oxidation also confirm some earlier results on the protein-sparing effects of carbohydrate intake. However, the data are extended to a population of middle-aged females not previously studied and at physiologic dietary intakes of carbohydrate, fat and protein where the average caloric intake was much less than previously reported and the protein intake greater than previously reported. The present data also underscored the marked increase in protein oxidation and the occurrence of negative nitrogen balance in subjects on the HF diet. Future studies on diet composition and energy metabolism at physiologic intake need to focus on longer exposures to HC and HF diets, include the population aged 65

and older, study activity levels and measures of well being comparatively under HC and HF conditions, and investigate further the long term health effects of diet composition on protein oxidation and its sequelae.

Finally, the current study confirms the concept that an isocaloric diet high in carbohydrate and low in fat alters total body weight and energy balance at normal, physiologic intakes. Therefore, the incorporation of a high carbohydrate-low fat pattern of eating may be a significant nutritional strategy along with control of total energy intake for achieving energy balance and weight control.

SUMMARY

The effect of an isocaloric, isonitrogeneous high carbohydrate diet vs. a high fat diet on energy expenditure was studied in crossover design in 13 healthy, never-obese, postmenopausal, Caucasian females after 22 days on each diet. The major findings and conclusions were as follows:

1. A significant total body weight loss (i.e., mean 0.47 kg) occurred after the HC diet. No significant weight change was seen after the HF diet. The mechanism for weight loss was not defined by the present study.
2. There were no significant changes in fat-free mass or fat mass after either diet.
3. RMR did not increase after the HC diet.
4. DIT showed a non-significant trend to be greater under the HC diet vs. the HF diet.
5. The substrate oxidation pattern reflected diet composition both fasting and postprandially. After HC intake, RQ and carbohydrate oxidation were increased while fat oxidation decreased. After HF intake the opposite pattern was observed.
6 Protein oxidation was significatnly lower and nitrogen balance significantly greater after the HC diet vs. the HF diet. That is, a protein-sparing effect was seen

after the HC diet. Five of 12 subjects were in a negative nitrogen balance after the HF diet.

7. Biochemical and hormone changes within and between diets were either physiologic or unchanged in the fasting and postprandial states.
8. In conclusion, diet composition at physiologic intake in healthy, middle-aged, Caucasian women alters total body weight and influences substrate oxidation patterns.

Table 1. Subject Characteristics[a]

Subject	Age y	Height cm	Weight kg	BMI[b]	% Fat
1	54	163.8	57.4	21.4	25.1
2	52	162.6	56.1	21.2	22.7
3	65	157.5	52.4	21.1	32.2
4	58	158.8	53.6	21.3	35.1
5	57	167.6	64.2	22.9	33.8
6	66	156.2	52.3	21.4	39
7	62	162.6	51.1	19.3	30.1
8	55	158.8	61.6	24.4	37.8
9	53	162.6	45.4	17.2	27.3
10	45	165.1	60.2	22.1	20.2
11	43	154.3	58.0	24.4	29.3
12	62	157.5	56.6	22.8	30.6
13	54	171.4	55.4	18.9	22.0
MEAN	56	161.4	55.7	21.4	29.6
SEM	2	1.3	1.4	0.6	1.7
RANGE	43-66	154.3-171.4	45.4-64.2	17.2-24.4	20.2-39.0

[a]Upon entry into study after 7 - 10 days on a standard Western diet

[b]Body mass index = weight in kilograms/height^2 in meters

Table 2. Composition of experimental diets at maintenance energy intake expressed as percent of total calorie intake

	Standard	HC	HF
Carbohydrate	48%	66%	30%
Fat	38%	20%	56%
Protein	14%	14%	14%

Standard = Typical Standard Western diet

HC = High carbohydrate-low fat

HF = High fat-low carbohydrate

Table 3. The Standard Western diet, HC diet, and HF diet provided to 13 healthy, postmenopausal, Caucasian females. The substrates are expressed in grams.

Subj.	Standard Western Diet				HC Diet				HF Diet			
	Total KCAL	PRO	FAT	CHO	KCAL	PRO	FAT	CHO	KCAL	PRO	FAT	CHO
#1	1560	54.6	65.9	187.2	1560	54.6	34.7	257.4	1555	54.4	96.8	116.6
#2	1560	54.6	65.9	187.2	1560	54.6	34.7	257.4	1555	54.4	96.8	116.6
#3	1560	54.6	65.9	187.2	1640	57.4	36.4	270.6	1630	57.1	101.4	122.3
#4	1560	54.6	65.9	187.2	1560	54.6	34.7	257.4	1550	65.11	96.4	116.3
#5	1560	54.6	65.9	187.2	1560	54.6	34.7	257.4	1555	54.4	96.8	116.6
#6	1400	49.0	59.1	168.0	1400	49.0	31.1	231.0	1400	49.0	87.1	105.0
#7	1400	49.0	59.1	168.0	1400	49.0	31.1	231.0	1400	49.0	87.1	105.0
#8	1640	57.4	69.2	196.8	1640	57.4	36.4	270.6	1700	59.5	105.8	127.5
#9	1720	60.2	72.6	206.4	1880	65.8	41.8	310.2	1860	65.1	115.7	139.5
#10	1640	57.4	69.2	196.8	1640	57.4	36.4	270.6	1700	59.5	105.8	127.5
#11	1560	54.6	65.9	187.2	1560	54.6	34.7	257.4	1550	54.3	96.4	116.3
#12	1400	49.0	59.1	168.0	1560	54.6	34.7	257.4	1555	54.4	96.8	116.6
#13	1560	54.6	65.9	187.2	1640	57.4	36.4	270.6	1630	57.1	101.4	122.3

Table 4. Total calorie (kcal) and protein (grams) intake per kilogram of body weight for 13 healthy, non-obese, postmenopausal, Caucasian females

Subject	kcal/kg	grams of protein/kg
1	27.1	.94
2	27.8	.97
3	31.3	1.09
4	29.1	1.01
5	24.3	.85
6	26.8	.94
7	27.4	.96
8	36.1	1.29
9	31.2	1.08
10	27.1	.95
11	26.9	.94
12	27.6	.96
13	29.5	1.03
n = 13		n = 13
Mean = 28.6		Mean = 1.00
SEM = 0.8		SEM = .03
Range = 24.3 - 36.1		Range = 0.85 - 1.29

Table 5. Summary of the mean difference in body composition after 22 days each of the HC diet and the HF diet, respectively

Body Compartment	After HC	p	After HF	p
	kg		kg	
Total body weight	-0.47	< .025	-0.1	> .10
Fat free mass	-0.42	.08	-0.26	> .10
Fat mass	-0.05	> .10	.08	> .10

HC = high carbohydrate-low fat diet

HF = high fat-low carbohydrate diet

Table 6. Summary of the differences in postprandial energy expenditure (DIT) for five 40-minute periods between the HC and HF diets[a] in 10 healthy, never-obese, postmenopausal Caucasian females

Period After Meal	Mean Difference[b] kcal	SEM	P
1 (1-40 minutes)	-0.4987	0.3168	0.075
2 (81-120)	-1.3533	0.9826	0.100
3 (161-200)	-1.0800	0.8303	0.120
4 (241-280)	-0.2557	0.2576	0.180
5 (321-360)	-0.3659	0.2440	0.080

HC = after a high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after a high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 7. Summary of the differences in cumulative postprandial energy expenditure (DIT) between the HC and HF challenge test meals[a] in 10 healthy, never-obese, postmenopausal Caucasian females

Time after meal	Mean difference[b]	SEM	P
minutes	cumulative kcal		
1 - 120	-2.9898	2.0415	0.09
1 - 200	-5.3641	3.8021	0.10
1 - 280	-6.3185	4.3407	0.09
1 - 360	-6.8281	4.5474	0.08

HC = after a high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after a high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 8. Summary of the differences in cumulative postprandial energy expenditure (DIT) expressed as kilocalories per kg fat-free mass (FFM) between the HC and HF challenge test meals[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

Time after meal	Mean Difference[b]	SEM	P
minutes	kcal/kg FFM		
1 - 120	-0.0721	0.0516	0.10
1 - 200	-0.1269	0.0957	0.11
1 - 280	-0.1475	0.1076	0.10
1 - 360	-0.1587	0.1118	0.09

HC = after a high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after a high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 9. Summary of the differences in cumulative postprandial energy expenditure (DIT) expressed in kilocalories as a percentage of ingested kilocalories between the HC and HF challenge test meals[a] in 10 healthy, never-obese, postmenopausal females

Time after meal	Mean difference[b]	SEM	P
minutes	% ingested kcal		
1 - 40	-0.0009	0.0006	0.08
1 - 120	-0.0050	0.0036	0.10
1 - 200	-0.0089	0.0067	0.11
1 - 280	-0.0103	0.0075	0.10
1 - 360	-0.0111	0.0078	0.09

HC = after a high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after a high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 10. Summary of the differences in RQ while fasting and for five 40-minute DIT periods[a] between the HC diet and the HF diet in 12 healthy, never-obese, postmenopausal, Caucasian females

Period after meal	Mean difference[b]	SEM	P
minutes	RQ		
Fasting	-0.06	0.03	< .025
1 (1 - 40)	-0.07	0.03	< .025
2 (82 - 120)	-0.12	0.04	< .010
3 (161 - 200)	-0.18	0.06	< .010
4 (241 - 280)	-0.18	0.05	< .005
5 (321 - 360)	-0.07	0.03	< .025

HC = after a high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after a high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 11. Summary of the differences in carbohydrate oxidation while fasting and for five 40-minute DIT[a] periods between the HC diet and the HF diet in 12 healthy, never obese, postmenopausal, Caucasian females

Period after meal	Mean difference[b]	SEM	P
Minutes	Grams		
Fasting	-55.75	26.60	< .05
1 (1-40)	-64.34	28.42	< .025
2 (81 - 120)	-141.19	40.20	< .005
3 (161 - 200)	-49.49	19.46	< .025
4 (241 - 280)	-51.28	22.7	< .025
5 (321 - 360)	-111.67	31.80	< .005

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 12. Summary of the differences in fasting biochemical substrate and hormone levels between the HC and HF diets after 22 days each in healthy, never-obese, postmenopausal, Caucasian females

SUBSTRATE OR HORMONE	n	MEAN DIFFERENCE[a]	SEM	P
Glucose	12	3.5 mg/dl	3.30	> .10
Insulin	10	-1.0 uU/ml	1.30	> .10
Glucagon	10	-15.0 pg/ml	36.00	> .10
Free Fatty Acids	12	-2.9 meq/l	57.30	> .10
Total Cholesterol	12	14.0 mg/dl	12.00	> .10
Triglyceride	12	-19.0 mg/dl	9.00	<.05[b]
T_4	10	-.03 ug/dl	0.17	> .10
T_3	8	-4.0 ug/dl	5.00	> .10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

Table 13. Difference in fasting biochemical substrate and hormone levels before and after 22 days on the HC and HF diets in healthy, never-obese, postmenopausal Caucasian females

SUBSTRATE OR HORMONE	DIET	n	MEAN DIFFERENCE[a]	SEM	P
Glucose	HC	12	1.0 mg/dl	4.50	> .10
Glucose	HF	12	10.9 mg/dl	3.60	< .025[b]
Insulin	HC	10	1.4 uU/ml	1.70	> .10
Insulin	HF	10	0.7 uU/ml	1.00	> .10
Glucagon	HC	10	-86.8 pg/ml	42.40	< .05[b]
Glucagon	HF	10	5.2 pg/ml	33.80	> .10
Free Fatty Acids	HC	12	183.8 meq/l	66.20	< .01[b]
Free Fatty Acids	HF	12	80.4 meq/l	84.00	> .10
Total Cholesterol	HC	12	-9.8 mg/dl	8.80	> .10
Total Cholesterol	HF	12	16.3 mg/dl	14.50	> .10
Triglyceride	HC	12	-16 mg/dl	11.00	.09
Triglyceride	HF	12	-34 mg/dl	17.00	< .05[b]
T_4	HC	10	.15 ug/dl	0.13	> .10
T_4	HF	10	-.05 ug/dl	0.09	> .10
T_3	HC	8	-3.5 ug/dl	5.20	> .10
T_3	HF	8	.4 ug/dl	6.30	> .10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days
HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days
a = comparison of differences in the direction of "after" minus "before"
b = statistical significance reached at $p < .05$

Fig. 1. Experimental Design

Purpose	Weight Stabilization	→	Isocaloric Isonitrogenous	→	BMC
Diet	Standard Western	→	HC or HF	→	
Living Condition	Free-Living	GCRC	Free-Living	GCRC	
1. Weights	Daily	Daily	Twice Weekly	Daily	
2. Underwater Weighing		*		*	
3. Biochemical			*		*
4. UUN				*	*
5. RMR					*
6. DIT					*
Time (days)	5-8	2	20	2	

HC = High Carbohydrate - low fat diet

HF = High Fat - low carbohydrate diet

GCRC = General Clinical Research Center at UAB

BMC = Baptist Medical Center Princeton

RMR = Resting Metabolic Rate

DIT = Diet-Induced Thermogenesis

UUN = Urinary Urea Nitrogen

Fig. 2. Difference in energy expenditure between the high carbohydrate diet and the high fat diet for 360 minutes after a challenge test meal in 10 healthy, never-obese, postmenopausal, Caucasian females

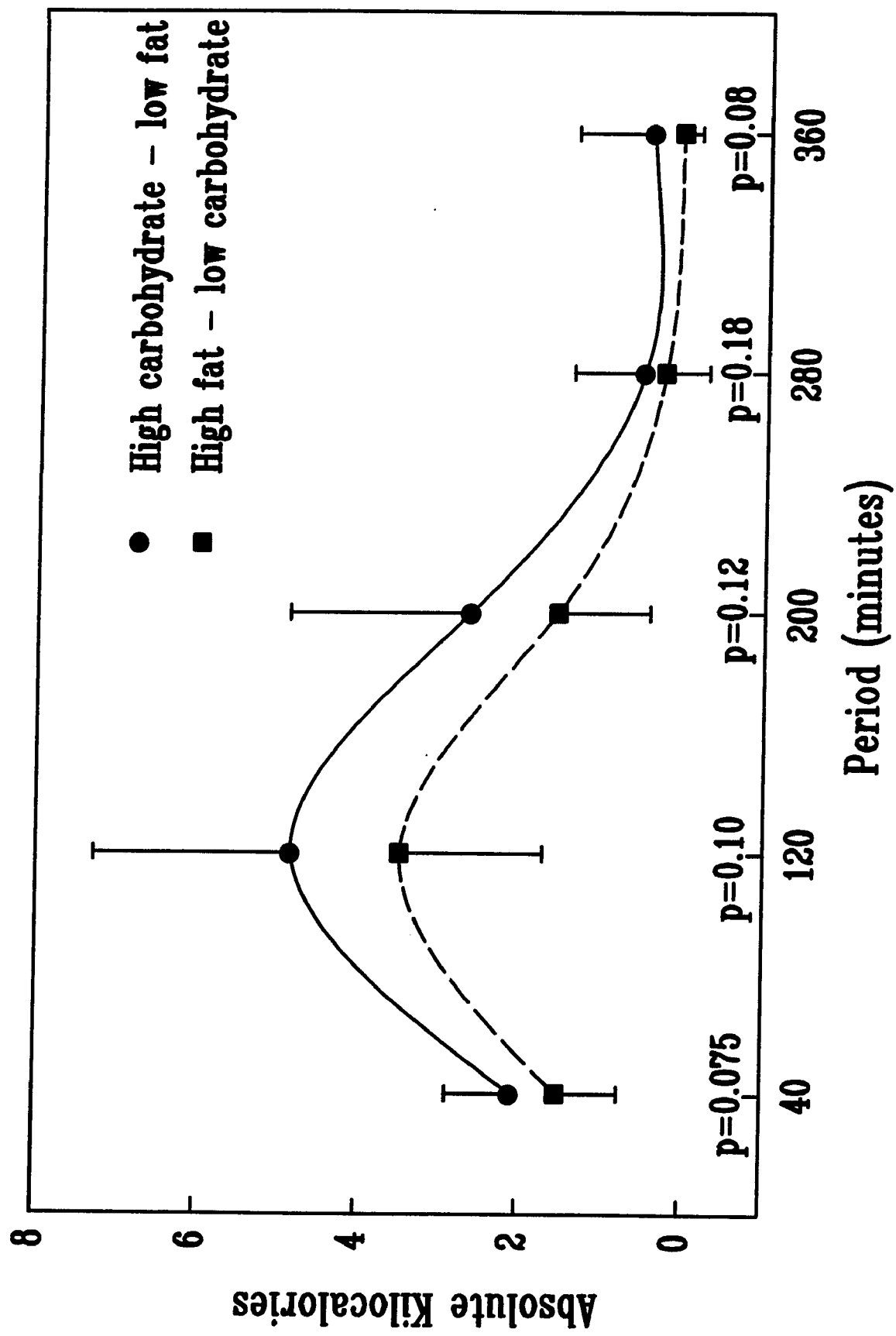

High carbohydrate – low fat
High fat – low carbohydrate
Absolute Kilocalories
0
2
4
6
8
Period (minutes)
40
120
200
280
360
p=0.075
p=0.10
p=0.12
p=0.18
p=0.08

Fig. 3. Difference in the cumulative energy expenditure between the high carbohydrate diet and the high fat diet for 360 minutes after a challenge test meal in 10 healthy, never-obese, postmenopausal, Caucasian females

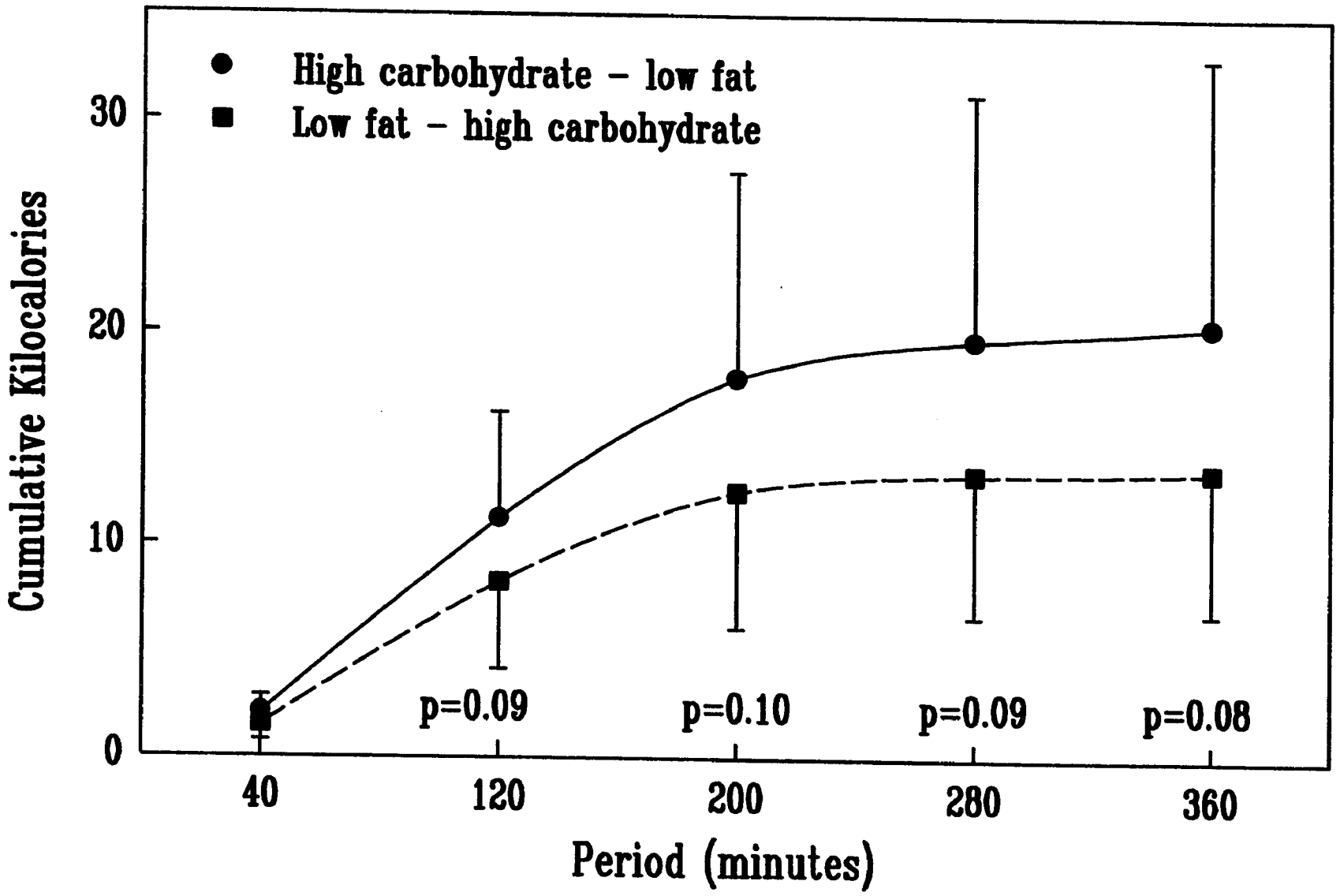

High carbohydrate – low fat
Low fat – high carbohydrate
Cumulative Kilocalories
30
20
10
0
p=0.09
p=0.10
p=0.09
p=0.08
40
120
200
280
360
Period (minutes)

Fig. 4. Difference in the cumulative energy expenditure expressed per fat-free mass between the high carbohydrate diet and the high fat diet for 360 minutes after a challenge test meal in 10 healthy, never-obese, postmenopausal, Caucasian females

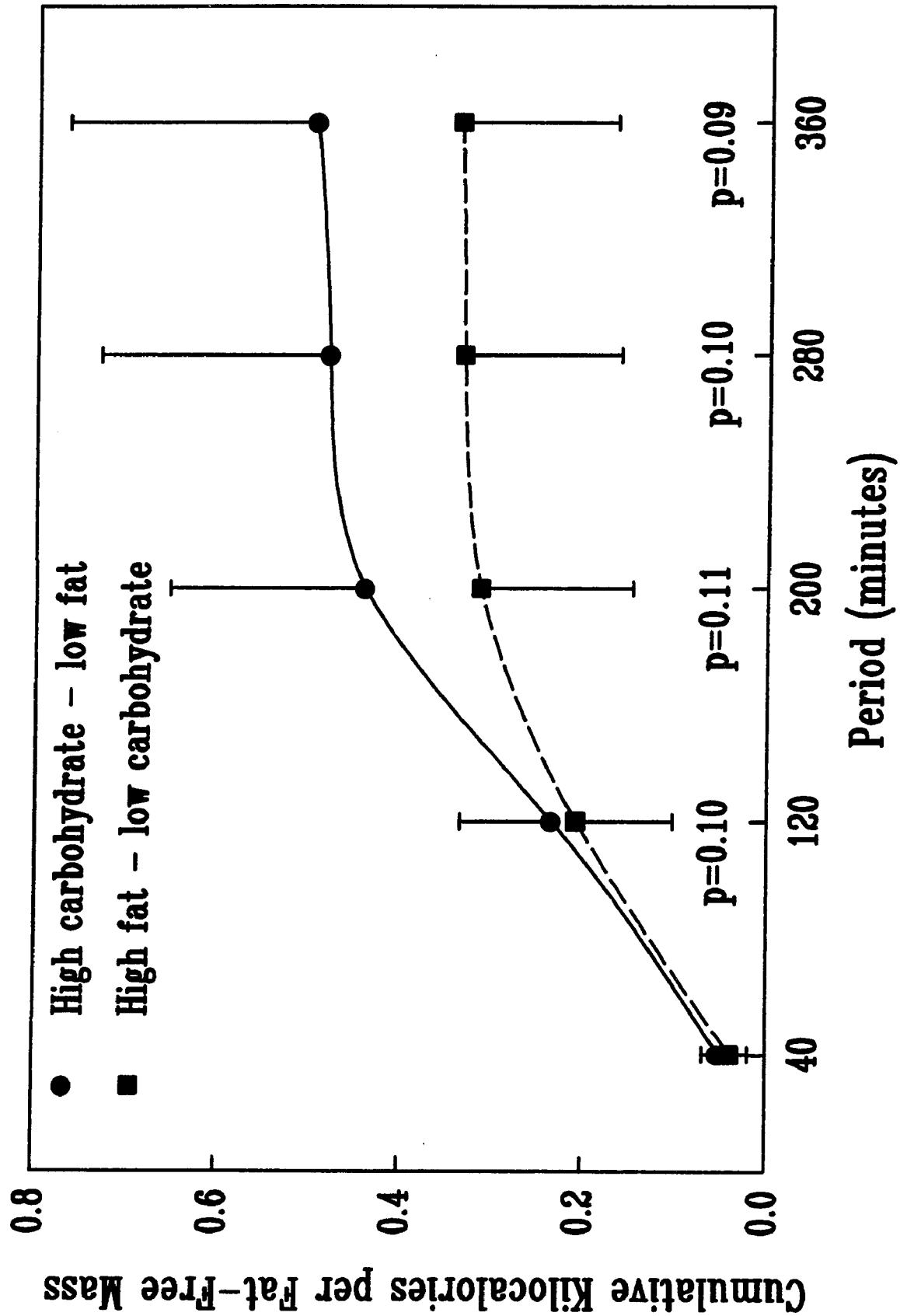

Cumulative Kilocalories per Fat-Free Mass
0.0
0.2
0.4
0.6
0.8
40
120
200
280
360
Period (minutes)
p=0.10
p=0.11
p=0.10
p=0.09
High carbohydrate - low fat
High fat - low carbohydrate

Fig. 5. Difference in the cumulative energy expenditure expressed as a percentage of calories ingested between the high carbohydrate diet and the high fat diet for 360 minutes after a challenge test meal in 10 healthy, never-obese, postmenopausal, Caucasian women

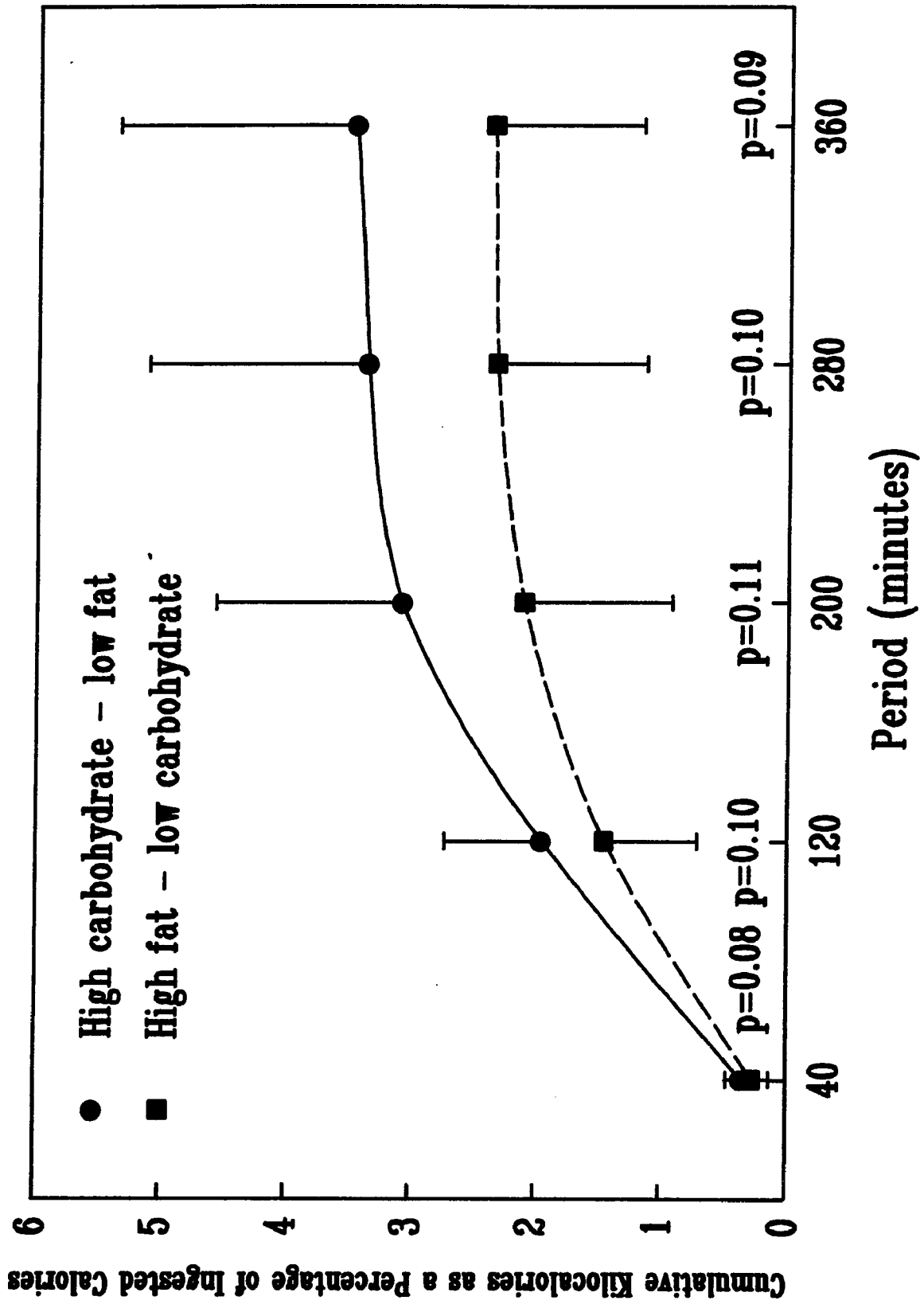

Cumulative Kilocalories as a Percentage of Ingested Calories
0
1
2
3
4
5
6
40
120
200
280
360
Period (minutes)
p=0.08
p=0.10
p=0.11
p=0.10
p=0.09
High carbohydrate - low fat
High fat - low carbohydrate

Fig. 6. Difference in the RQ between the high carbohydrate diet and the high fat diet while fasting and for 360 minutes after a challenge test meal in 12 healthy, never-obese, postmenopausal, Caucasian females

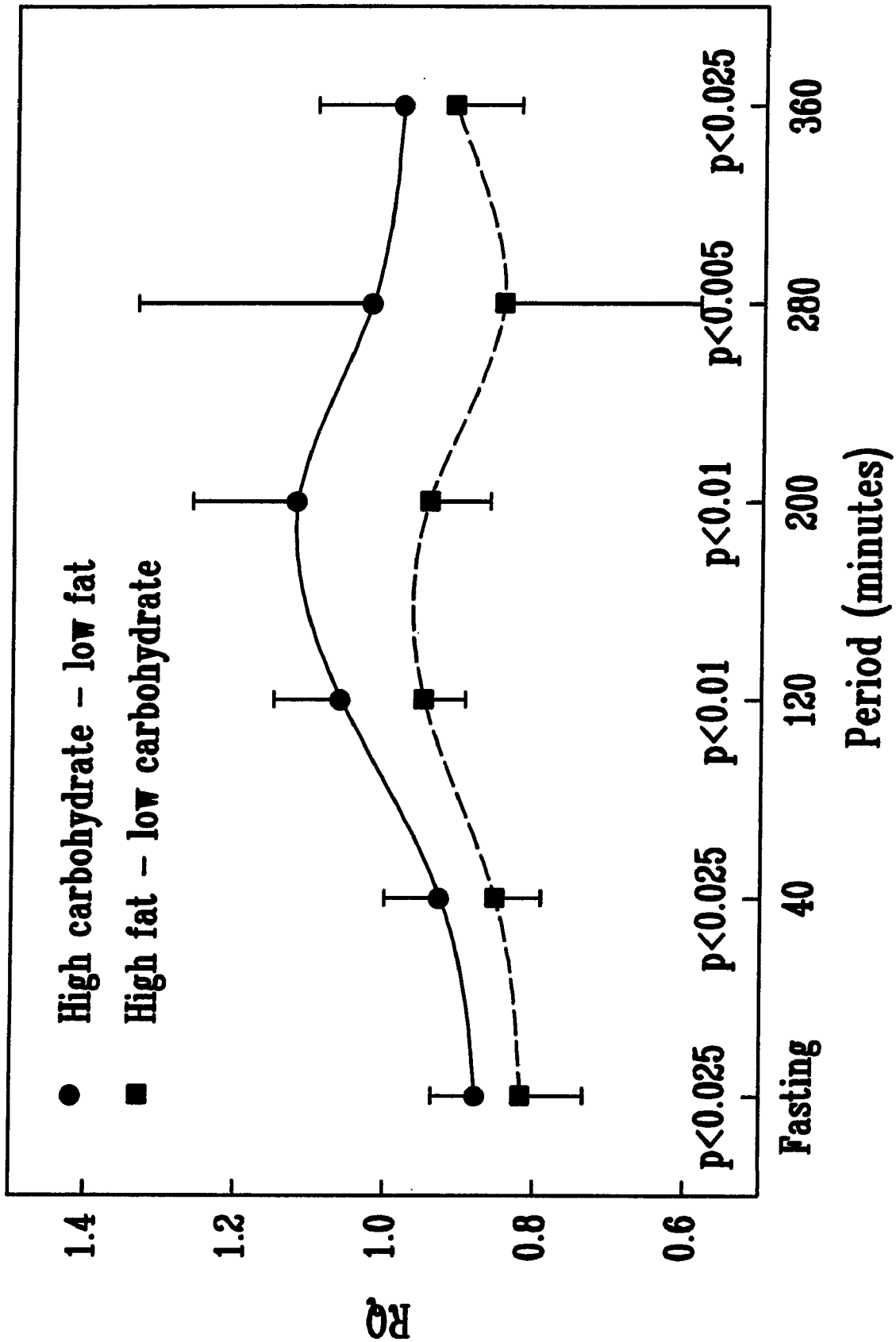

High carbohydrate – low fat
High fat – low carbohydrate
RQ
1.4
1.2
1.0
0.8
0.6
p<0.025
p<0.025
p<0.01
p<0.01
p<0.005
p<0.025
Fasting
40
120
200
280
360
Period (minutes)

Fig. 7. Difference in the change in glucose concentration between the high carbohydrate diet and the high fat diet 360 minutes after a challenge test meal in 13 healthy, never-obese, postmenopausal, Caucasian females

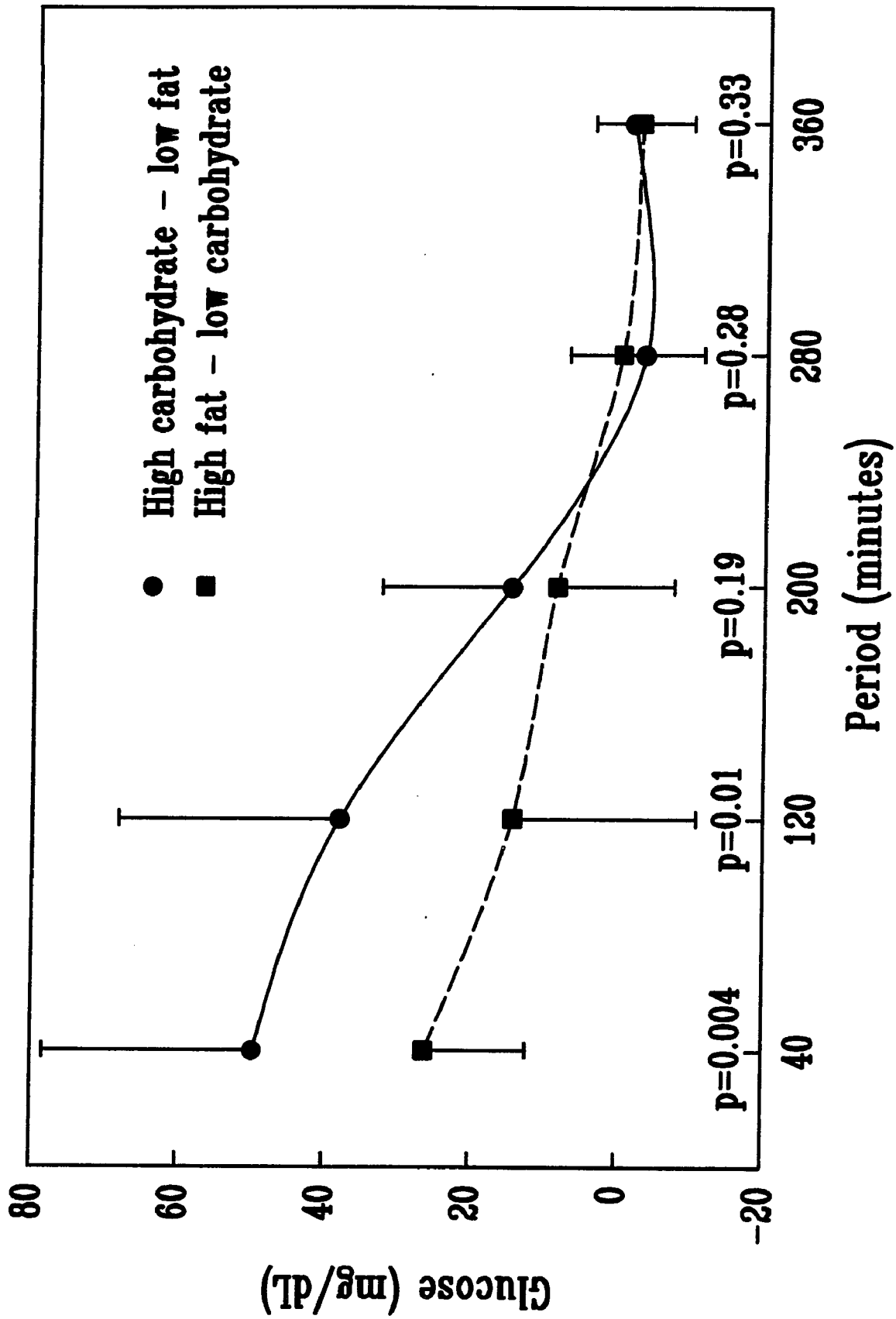

High carbohydrate – low fat
High fat – low carbohydrate
Glucose (mg/dL)
80
60
40
20
0
-20
40
120
200
280
360
Period (minutes)
p=0.004
p=0.01
p=0.19
p=0.28
p=0.33

Fig. 8. Difference in the change in insulin concentration between the high carbohydrate diet and the high fat diet 360 minutes after a challenge test meal in 12 healthy, never-obese, postmenopausal, Caucasian females

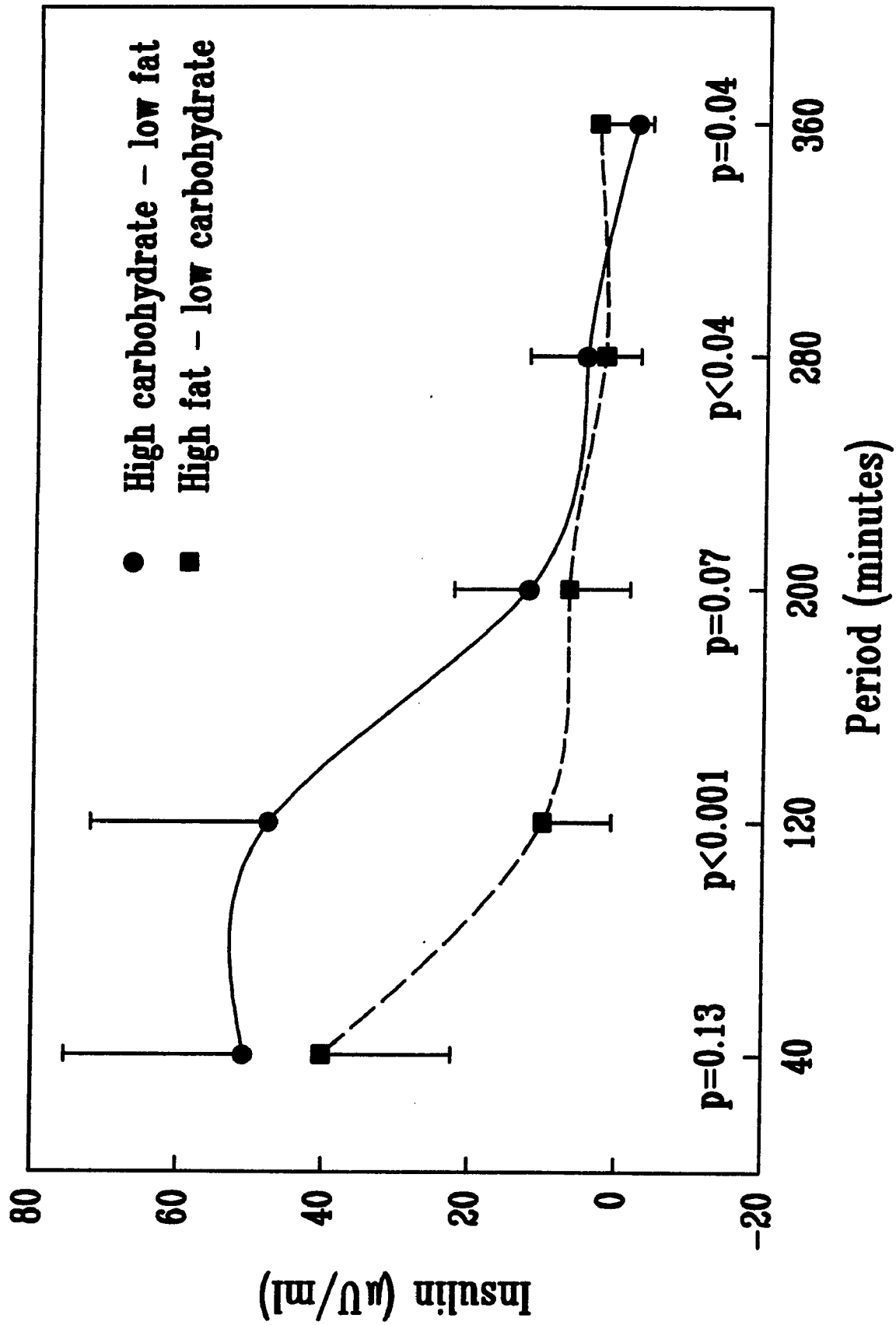

High carbohydrate – low fat
High fat – low carbohydrate
Insulin (μU/ml)
80
60
40
20
0
-20
40
120
200
280
360
Period (minutes)
p=0.13
p<0.001
p=0.07
p<0.04
p=0.04

Fig. 9. Difference in the change in glucagon concentration between the high carbohydrate diet and the high fat diet 360 minutes after a challenge test meal in 11 healthy, never-obese, postmenopausal, Caucasian females

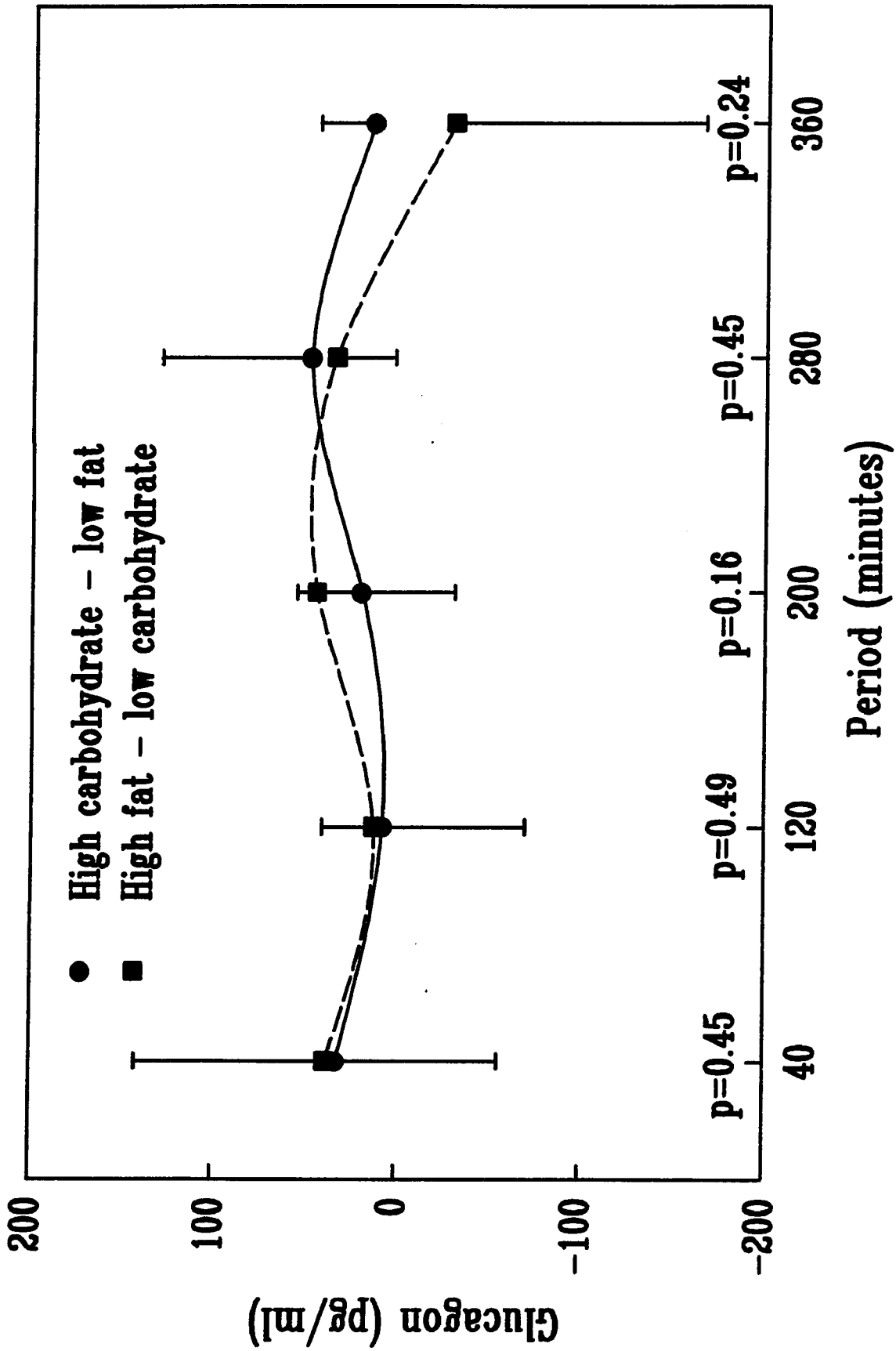
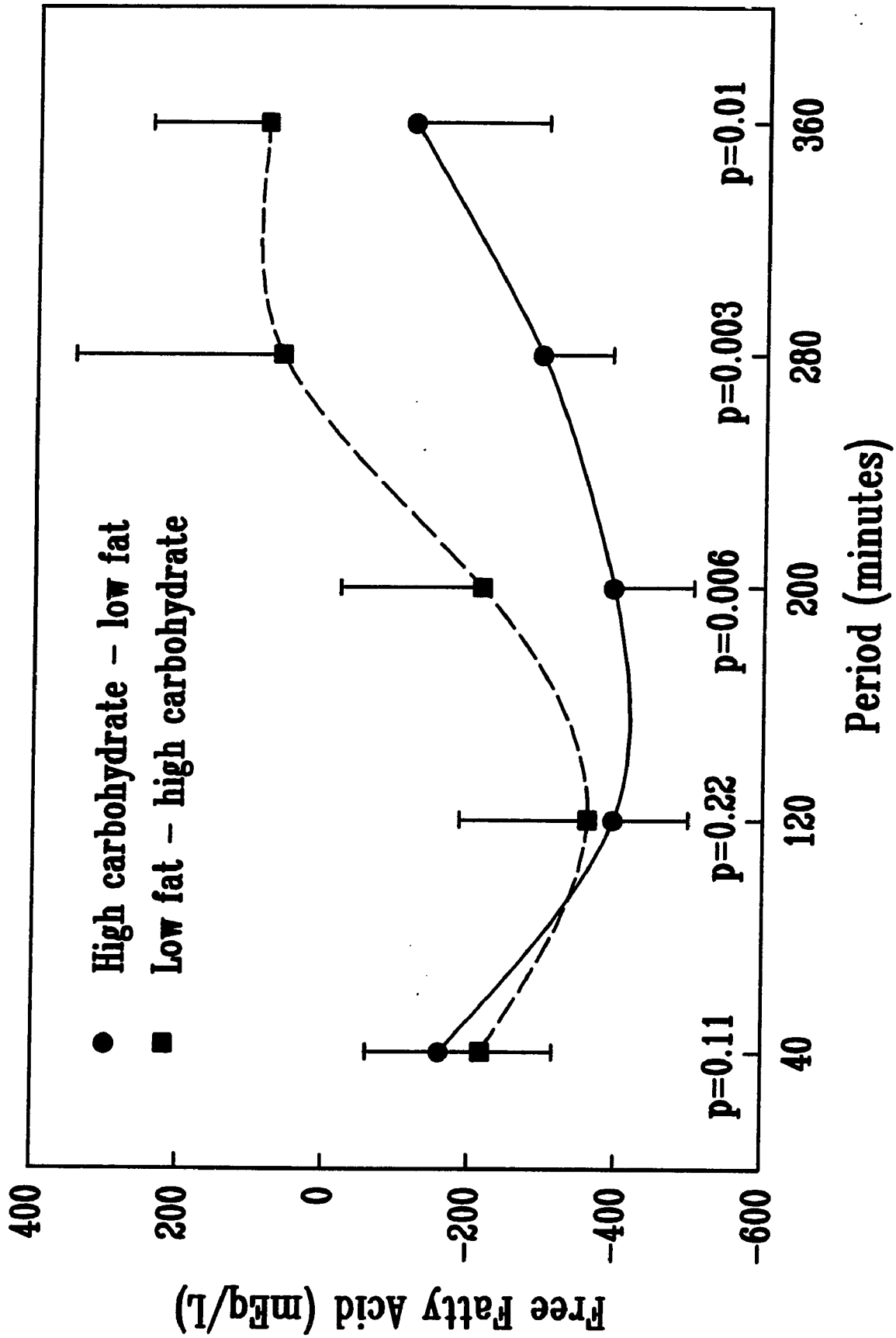

Glucagon (pg/ml)
200
100
0
-100
-200
40
120
200
280
360
Period (minutes)
p=0.45
p=0.49
p=0.16
p=0.45
p=0.24
High carbohydrate - low fat
High fat - low carbohydrate

Fig. 10. Difference in the change in free fatty acid concentration between the high carbohydrate diet and the high fat diet 360 minutes after a challenge test meal in 12 healthy, never-obese, postmenopausal, Caucasian females


High carbohydrate – low fat
Low fat – high carbohydrate
Free Fatty Acid (mEq/L)
400
200
0
-200
-400
-600
p=0.11
p=0.22
p=0.006
p=0.003
p=0.01
40
120
200
280
360
Period (minutes)

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APPENDIX

Table 1. Difference in total body weight after 22 days on maintenance energy intake of a high carbohydrate-low fat diet in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	kg	kg	kg
1	57.27	57.38	0.11
2	57.27	56.13	-1.14
3	52.50	50.63	-1.87
4	53.40	53.18	-0.22
5	64.77	64.09	-0.68
6	51.82	51.36	-0.46
7	50.91	50.80	-0.11
8	44.43	45.00	0.57
9	61.48	60.91	-0.57
10	60.00	58.86	-1.14
11	57.27	57.16	-0.11
12	55.45	55.68	0.23
13	55.45	54.77	-0.68

n = 13
mean = -0.47
SEM = 0.18
p < 0.025

a = comparison of differences in the direction of "after" minus "before"

Table 2. Difference in total body weight after 22 days on maintenance energy intake of a high fat-low carbohydrate diet in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	kg	kg	kg
1	56.81	57.72	0.91
2	56.36	56.36	0.00
3	53.64	52.39	-1.25
4	53.18	52.84	-0.34
5	64.32	62.73	-1.59
6	52.27	51.93	-0.34
7	51.36	50.90	-0.46
8	44.77	44.89	-0.12
9	60.45	61.59	1.14
10	59.54	59.20	-0.34
11	58.64	58.20	-0.44
12	56.82	57.61	0.79
13	56.12	56.59	0.47

n = 13
mean = -0.1
SEM = 0.22
p > 0.10

a = comparison of differences in the direction of "after" minus "before"

Table 3. Difference in fat-free mass after 22 days on maintenance energy intake of a high carbohydrate-low fat diet in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	kg	kg	kg
1	42.90	43.21	0.31
2	44.27	43.45	-0.82
3	35.28	34.63	-0.65
4	34.66	35.10	0.44
5	42.88	41.66	-1.22
6	33.27	33.74	0.47
7	35.22	34.95	-0.27
8	32.30	32.27	0.42
9	38.24	38.98	0.74
10	48.00	48.44	0.44
11	41.12	38.76	-2.36
12	38.57	37.45	-1.12
13	44.58	42.72	-1.86

n = 13
mean = -0.42
SEM = 0.28
p = 0.08

a = comparison of differences in the direction of "after" minus "before"

Table 4. Difference in fat-free mass after 22 days on maintenance energy intake of a high fat-low carbohydrate diet in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	kg	kg	kg
1	42.84	43.35	0.51
2	43.85	44.41	0.56
3	336.37	34.00	-1.37
4	35.79	37.72	-0.07
5	41.68	40.15	-1.53
6	31.89	32.30	0.41
7	36.20	34.57	-1.63
8	31.57	32.82	1.25
9	39.93	39.73	-0.20
10	48.17	49.02	0.85
11	41.45	39.17	-2.29
12	39.43	39.18	-0.25
13	43.77	44.14	0.37

n = 13
mean = -0.26
SEM = 0.3049
p > 0.10

a = comparison of differences in the direction of "after" minus "before"

Table 5. Difference in fat mass after 22 days on maintenance energy intake of a high carbohydrate-low fat diet in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	kg	kg	kg
1	14.37	14.17	-0.20
2	13.00	12.68	-0.32
3	17.22	16.00	-1.22
4	18.74	18.08	-0.66
5	21.89	22.43	0.54
6	18.55	17.62	-0.93
7	15.68	15.85	0.17
8	12.13	12.28	0.15
9	23.24	21.93	-1.31
10	12.00	10.42	-1.58
11	16.15	18.40	2.25
12	16.88	18.21	1.33
13	10.87	12.05	1.18

n = 13
mean = -0.5
SEM = 0.32
p > 0.10

a = comparison of differences in the direction of "after" minus "before"

Table 6. Difference in fat mass after 22 days on maintenance energy intake of a high fat-low carbohydrate diet in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	kg	kg	kg
1	13.97	14.37	0.40
2	12.51	11.95	-0.56
3	17.27	17.39	0.12
4	17.39	17.12	-0.27
5	22.64	22.58	-0.06
6	20.38	19.63	-0.75
7	15.16	16.33	1.17
8	13.20	12.07	-1.13
9	21.52	21.86	0.34
10	11.37	10.18	-1.19
11	17.18	19.05	1.87
12	17.39	18.43	1.04
13	12.35	12.45	0.10

n = 13
mean = 0.08
SEM = 0.25
p > 0.10

a = comparison of differences in the direction of "after" minus "before"

Table 7. Difference in the relative changes in total body weight between the HC diet vs the HF diet after 22 days on each in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC[a]	HF[b]	DIFFERENCE[c]
	kg	kg	kg
1	0.11	0.91	0.80
2	-1.14	0.00	1.14
3	-1.87	-1.25	0.62
4	-0.22	-0.34	-0.12
5	-0.68	-1.59	-0.91
6	-0.46	-0.34	0.12
7	-0.11	-0.46	-0.35
8	0.57	0.12	-0.45
9	-0.57	1.14	0.57
10	-1.14	-0.34	-0.80
11	-0.11	-0.44	-0.33
12	0.23	0.79	0.56
13	-0.68	0.47	1.15

n = 13
mean = 0.28
SEM = 0.18
p = 0.08

HC = high carbohydrate-low fat diet

HF = high fat-low carbohydrate diet

a = A positive number in the HC column indicates that total body weight increased after 22 days under the HC condition. A negative value indicates a decrease.

b = A positive number in the HF column indicates that total body weight increased after 22 days under the HF condition. A negative value indicates a decrease.

c = comparison in the direction of HF minus HC

Table 8. Difference in the relative changes in fat-free mass between the HC diet and the HF diet after 22 days on each in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC[a]	HF[b]	DIFFERENCE[c]
	kg	kg	kg
1	0.31	0.51	0.20
2	-0.82	0.56	1.38
3	-0.65	-1.37	-0.72
4	0.44	-0.07	-0.51
5	-1.22	-1.53	-0.31
6	0.47	0.41	-0.06
7	-0.27	-1.63	-1.36
8	0.42	1.25	0.83
9	0.74	-0.20	0.94
10	0.44	0.85	0.41
11	-2.36	-2.29	0.07
12	-1.12	-0.25	0.87
13	-1.86	0.37	2.23

n = 13
mean = 0.16
SEM = 0.27
p > 0.10

HC = high carbohydrate-low fat diet

HF = high fat-low carbohydrate diet

a = A positive number in the HC column indicates that fat-free mass increased after 22 days under the HC condition. A negative value indicates a decrease.

b = A positive number in the HF column indicates that fat-free mass increased after 22 days under the HF condition. A negative value indicates a decrease.

c = comparison in the direction of HF minus HC

Table 9. Difference in the relative changes in fat mass between the HC diet and the HF diet after 22 days on each in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC[a]	HF[b]	DIFFERENCE[c]
	kg	kg	kg
1	-0.20	0.40	0.60
2	-0.32	-0.56	-0.24
3	-1.22	0.12	1.34
4	-0.66	-0.27	0.39
5	0.54	-0.06	-0.60
6	-0.93	-0.75	0.18
7	0.17	1.17	1.00
8	0.15	-1.13	-1.28
9	-1.31	0.34	1.65
10	-1.58	-1.19	0.39
11	2.25	1.87	-0.38
12	1.33	1.04	-0.29
13	1.18	0.10	-1.08

n = 13
mean = 0.13
SEM = 0.25
p > 0.10

HC = high carbohydrate-low fat diet

HF = high fat-low carbohydrate diet

a = A positive number in the HC column indicates that fat mass increased after 22 days under the HC condition. A negative value indicates a decrease.

b = A positive number in the HF column indicates that fat mass increased after 22 days under the HF condition. A negative value indicates a decrease.

c = comparison in the direction of HF minus HC

Table 10. Difference in the resting energy expenditure between the HC diet and the HF diet after 22 days each in 13 healthy, never-obese, postmenopausal, Caucasian females.

SUBJECT	CHO	FAT	DIFFERENCE[a]
	kcal/24h	kcal/24h	kcal/24h
1	9971.37	1016.37	45.00
2	1002.09	1000.28	-1.81
3	1000.08	1037.74	37.66
4	1136.84	1128.91	-7.93
5	1205.55	1153.61	-51.94
6			
7	1168.09	1155.04	-13.05
8	745.87	977.19	231.32
9	1082.98	1192.55	109.57
10	1251.72	1253.40	11.68
11	1100.79	1279.92	178.13
12	1068.77	1195.54	126.77
13	1331.59	1256.24	-75.35

n = 12
mean = 49.17
SEM = 27.03
p < 0.05

HC = high carbohydrate-low fat diet at maintenance energy intake
HF = high fat-low carbohydrate diet at maintenance energy intake
a = comparison of differences in the direction of "after" minus "before"

Table 11. Difference in energy expenditure between the HC diet and the HF diet 1 - 40 minutes (period 1) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
	kcal	kcal	kcal
1	3.7352	2.555	-1.1797
2	1.5595	2.0562	0.4967
3			
4	1.7523	1.0158	-0.7365
5	2.4434	1.6758	-0.7676
6			
7	1.4432	2.8495	1.4063
8	2.0870	0.9423	-1.1447
9	0.9171	1.3773	0.4602
10	2.2937	0.6883	-1.6054
11	2.2905	0.6850	-1.6055
12	1.6664	1.3553	-0.3110
13			

n = 10
mean = -0.4987
SEM = 0.3168
p = 0.075

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 12. Difference in energy expenditure between the HC diet and the HF diet 81 - 120 minutes (period 2) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	9.7438	5.7677	-3.9761
2	4.4808	4.5254	0.0446
3			
4	4.3234	1.4922	-2.8312
5	6.5858	3.6203	-2.9655
6			
7	1.5785	6.5157	4.9372
8	4.5039	1.7609	-2.7430
9	1.6584	4.0111	2.3527
10	6.3701	2.1196	-4.2505
11	5.7576	1.6241	-4.1335
12	3.3881	3.4202	0.0321
13			

n = 10
mean = -1.3533
SEM = 0.9826
p = 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 13. Difference in energy expenditure between the HC diet and the HF diet 161 - 200 minutes (period 3) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	6.4889	2.3208	-4.1684
2	3.6459	1.8141	-1.8313
3			
4	2.1063	0.0000	-2.1063
5	4.0521	0.9370	-3.1151
6			
7	0.0000	2.5642	2.5642
8	1.2433	0.0685	-1.1748
9	0.0245	3.3420	3.3175
10	5.0610	2.0307	-3.0303
11	3.2635	0.4098	-2.8537
12	0.4055	2.0037	1.5982
13			

n = 10
mean = -1.0800
SEM = 0.8303
p = 0.12

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 14. Difference in energy expenditure between the HC diet and the HF diet 241 - 280 minutes (period 4) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	1.3886	0.0000	-1.3885
2	1.3281	0.0000	-1.3281
3			
4	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000
6			
7	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000
9	0.0000	1.2707	1.2707
10	2.4258	1.2796	-1.1462
11	0.0203	0.0000	-0.0203
12	0.0000	0.0559	0.0559
13			

n = 10
mean = -0.2557
SEM = 0.2576
p = 0.18

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 15. Difference in energy expenditure between the HC diet and the HF diet 321 - 360 minutes (period 5) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	1.8596	0.0000	-1.8596
2	0.0000	0.0000	0.0000
3			
4	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000
6			
7	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000
10	2.5242	0.7244	-1.7998
11	0.0000	0.0000	0.0000
12	0.0000	0.0000	0.0000
13			

n = 10
mean = -0.3659
SEM = 0.2440
p = 0.08

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 16. Difference in the cumulative energy expenditure between the HC diet and the HF diet 1 - 120 minutes (through period 2) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	21.8400	13.7397	-8.1003
2	9.6721	10.8925	1.2205
3			
4	9.9277	4.4111	-5.5166
5	14.5965	8.8009	-5.7956
6			
7	5.5302	15.4418	9.9116
8	10.9512	4.5837	-6.3675
9	4.3891	8.6142	4.2251
10	13.9226	4.4555	-8.6539
11	13.1094	3.8026	-9.3068
12	8.4742	7.7732	-0.7010
13			

n = 10
mean = -2.9898
SEM = 2.0415
p = 0.09

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 17. Difference in the cumulative energy expenditure between the HC diet and the HF diet 1 - 200 minutes (through period 3) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	37.1400	20.5147	-16.6253
2	17.7088	16.1514	-1.5574
3			
4	15.6317	4.7309	-10.9008
5	24.5840	12.3165	-12.2675
6			
7	5.6221	23.0563	17.4342
8	15.4208	5.6008	-9.8200
9	5.2238	15.9268	10.7030
10	25.1186	8.6978	-16.4208
11	21.3366	5.4277	-15.9089
12	11.0266	12.7492	1.7226
13			

n = 10
mean = -5.3641
SEM = 3.8021
p = 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 18. Difference in the cumulative energy expenditure between the HC diet and the HF diet 1 - 280 minutes (through period 4) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	42.2347	20.8585	-21.3762
2	21.5672	16.5358	-5.0314
3			
4	16.0249	4.7309	-11.2940
5	25.9587	12.3165	-13.6422
6			
7	6.6221	23.3302	17.7081
8	15.4208	5.6008	-9.8200
9	5.2238	19.5604	14.3366
10	31.1998	11.6617	-29.5381
11	22.5983	5.4277	-17.1706
12	11.0266	113.6694	2.6428
13			

n = 10
mean = -6.3185
SEM = 4.3407
p = 0.09

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 19. Difference in the cumulative energy expenditure between the HC and the HF diet 1 - 360 minutes (through period 5) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	44.5584	20.8585	-23.6999
2	21.8923	16.5358	-5.3565
3			
4	16.0249	4.7309	-11.294
5	25.9587	12.3165	-13.6422
6			
7	5.6221	23.3302	-17.7081
8	15.4208	5.6008	-9.8200
9	5.2238	19.8684	14.6446
10	35.6036	13.3100	-22.2936
11	22.5983	5.4277	-17.1706
12	11.0266	13.6694	2.6428
13			

n = 10
mean = -6.8281
SEM = 4.5474
p = 0.08

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 20. Difference in the cumulative energy expenditure expressed per fat-free mass between the HC diet and the HF diet 1 - 120 minutes (through period 2) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	0.5091	0.3207	-0.1884
2	0.2185	0.2484	0.0299
3			
4	0.2864	0.1233	-0.1631
5	0.3404	0.2112	-0.1292
6			
7	0.1570	0.4266	0.2696
8	0.3391	0.1452	-0.1939
9	0.1148	0.2157	0.3305
10	0.2901	0.0925	-0.1976
11	0.3188	0.0917	-0.2271
12	0.2197	0.1971	-0.0226
13			

n = 10
mean = -0.0721
SEM = 0.0516
p = 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 21. Difference in the cumulative energy expenditure expressed per fat-free mass between the HC diet and the HF diet 1 - 200 minutes (through period 3) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	0.8657	0.4789	-0.3868
2	0.4000	0.3683	-0.0317
3			
4	0.4510	0.1322	-0.3188
5	0.5733	0.2955	-0.2778
6			
7	0.1596	0.6369	0.4773
8	0.4774	0.1774	0.6548
9	0.1366	0.3989	0.2623
10	0.5233	0.1806	-0.3427
11	0.5189	0.1309	-0.3880
12	0.2859	0.3233	0.0374
13			

n = 10
mean = -0.1269
SEM = 0.0957
p = 0.11

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 22. Difference in the cumulative energy expenditure expressed per fat-free mass between the HC diet and the HF diet 1 - 280 minutes (through period 4) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	0.9845	0.4869	-0.4976
2	0.4872	0.3771	-0.1101
3			
4	0.4624	0.1322	-0.3302
5	0.6054	0.2955	-0.3099
6			
7	0.1596	0.6445	0.4849
8	0.4774	0.1774	-0.3000
9	0.1355	0.4899	0.3533
10	0.6500	0.2421	-0.4079
11	0.5496	0.1309	-0.4187
12	0.2859	0.3467	0.0608
13			

n = 10
mean = -0.1475
SEM = 0.1076
p = 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 23. Difference in the cumulative energy expenditure expressed per fat-free mass between the HC diet and the HF diet 1 - 360 minutes (through period 5) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	1.0387	0.4869	-0.5518
2	0.4945	0.3771	-0.1174
3			
4	0.4624	0.1322	-0.3302
5	0.6054	0.2955	-0.3099
6			
7	0.1596	0.6445	0.4849
8	0.4774	0.1774	-0.3000
9	0.1366	0.4976	0.3610
10	0.7417	0.2763	-0.4654
11	0.5496	0.1309	-0.4187
12	0.2859	0.3467	0.0608
13			

n = 10
mean = -0.1587
SEM = 0.1118
p = 0.09

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 24. Difference in the cumulative energy expenditure expressed as a percentage of calories ingested between the HC diet and the HF diet 1 - 40 minutes (through period 1) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	0.6089	0.4172	-0.1917
2	0.2463	0.3279	0.0816
3			
4	0.3535	0.1985	-0.1550
5	0.3981	0.2812	-0.1169
6			
7	0.2865	0.5505	0.2640
8	0.4518	0.2087	-0.2431
9	0.1677	0.2412	0.0735
10	0.3342	0.0999	-0.2343
11	0.3895	0.1155	-0.2740
12	0.3021	0.2404	-0.0617
13			

n = 10
mean = -0.0009
SEM = 0.0006
p = 0.08

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 25. Difference in the cumulative energy expenditure expressed as a percentage of calories ingested between the HC diet and the HF diet 1 - 120 minutes (through period 2) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	3.5601	2.2428	-1.3173
2	1.5278	1.7371	0.2093
3			
4	2.0030	0.8619	-1.1411
5	2.3780	1.4766	-0.9014
6			
7	1.0980	2.9830	1.8850
8	2.3710	1.0153	-1.3557
9	0.8026	1.5086	0.7060
10	2.0284	0.6468	-1.3816
11	2.2294	0.6414	-1.5880
12	1.5364	1.3786	-0.1578
13			

n = 10
mean = -0.0050
SEM = 0.0036
p = 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 26. Difference in the cumulative energy expenditure expressed as a percentage of calories ingested between the HC diet and the HF diet 1 - 200 (through period 3) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	6.0541	3.3487	-2.7054
2	2.7973	2.5957	-0.2216
3			
4	3.1538	0.9244	-2.2294
5	4.0052	2.0665	-1.9387
6			
7	1.1163	4.4539	3.3376
8	3.3386	1.2406	-2.0980
9	0.9553	2.7893	1.8340
10	3.6595	1.2627	-2.3968
11	3.6286	0.9155	-2.7131
12	1.9992	1.3786	-0.6206
13			

n = 10
mean = -0.0089
SEM = 0.0067
p = 0.11

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 27. Difference in the cumulative energy expenditure expressed as a percentage of calories ingested between the HC diet and HF diet 1 - 280 minutes (through period 4) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	6.8846	3.4049	-3.4797
2	3.4068	2.6370	-0.7698
3			
4	3.2332	0.9244	-2.3088
5	4.2292	2.0665	-2.1627
6			
7	1.1163	4.5069	3.3906
8	3.3386	1.2406	-2.0980
9	0.9553	3.4256	2.4703
10	4.5454	1.6930	-2.8524
11	3.8431	0.9155	-2.9276
12	1.9992	2.4243	0.4251
13			

n = 10
mean = -0.0103
SEM = 0.0075
p = 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 28. Difference in the cumulative energy expenditure expressed as a percentage of calories ingested between the HC diet and the HF diet 1 - 360 minutes (through period 5) after a challenge test meal[a] in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	7.2633	3.4049	-3.8584
2	3.4582	2.6370	-0.7945
3			
4	3.2332	0.9244	-2.3088
5	4.2292	2.0665	-2.1627
6			
7	1.1163	4.5069	3.3906
8	3.3386	11.2406	-2.098
9	0.9553	3.4796	2.5243
10	5.1870	1.9323	-3.2547
11	3.8431	0.9155	-2.9276
12	1.9992	2.4243	0.4251
13			

n = 10
mean = -0.0111
SEM = 0.0078
p = 0.09

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 29. Difference in RQ between the HC diet and the HF diet while fasting in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
1	0.96	0.91	-0.05
2	0.93	0.87	-0.06
3	0.92	0.93	0.01
4	0.84	0.80	-0.04
5	0.77	0.92	0.15
6			
7	0.81	0.70	-0.11
8	0.86	0.81	-0.05
9	0.95	0.82	-0.13
10	0.83	0.85	0.02
11	0.91	0.72	-0.19
12	0.89	0.78	-0.11
13	0.86	0.70	-0.16

n = 12
mean = -0.06
SEM = 0.03
p < 0.025

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = comparison of differences in the direction of HF minus HC

Table 30. Difference in RQ between the HC diet and the HF diet 1 - 40 minutes post meal challenge[a] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	0.91	0.95	0.04
2	0.94	0.87	-0.07
3	0.88	0.83	-0.05
4	0.84	0.89	0.05
5	0.80	0.90	0.10
6			
7	0.99	0.77	-0.22
8	1.07	0.93	-0.14
9	0.98	0.83	-0.15
10	0.88	0.89	0.01
11	0.98	0.77	-0.21
12	0.96	0.83	-0.13
13	0.89	0.78	-0.11

n = 12
mean = -0.07
SEM = 0.03
p = 0.025

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 31. Difference in RQ between the HC diet and the HF diet 81 - 120 minutes post meal challenge[a] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	1.00	1.02	0.02
2	1.06	0.98	-0.08
3	1.01	0.93	0.08
4	0.94	1.02	0.08
5	0.92	1.00	0.08
6			
7	1.20	0.84	-0.36
8	1.16	0.90	-0.26
9	1.13	0.94	-0.19
10	1.02	1.00	-0.02
11	1.03	0.84	-0.19
12	1.16	0.92	-0.24
13	1.10	0.91	-0.19

n = 12
mean = -0.12
SEM = 0.04
p < 0.01

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 32. Difference in RQ between the HC diet and the HF diet 161 - 200 minutes post meal challenge[a] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	1.08	1.03	-0.05
2	1.05	1.03	-0.02
3	0.96	0.90	-0.06
4	1.00	1.08	0.08
5	0.98	1.03	0.05
6			
7	1.43	0.82	-0.61
8	1.22	0.91	-0.31
9	1.15	0.93	-0.22
10	1.04	0.93	-0.11
11	1.05	0.87	-0.18
12	1.28	0.94	-0.34
13	1.21	0.86	-0.35

n = 12
mean = -0.18
SEM = 0.06
p < 0.01

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 33. Difference in RQ between the HC diet and the HF diet 241 - 280 minutes post meal challenge[a] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	1.04	1.02	-0.02
2	1.02	0.93	-0.09
3	0.90	0.84	-0.06
4	0.98	1.04	0.06
5	0.96	1.02	0.06
6			
7	1.28	0.81	-0.47
8	1.26	0.99	-0.27
9	1.14	0.89	-0.25
10	1.09	0.91	-0.18
11	1.04	0.93	-0.11
12	1.39	0.93	-0.46
13	1.17	0.85	-0.32

n = 12
mean = -0.18
SEM = 0.05
p < 0.005

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 34. Difference in RQ between the HC diet and the HF diet 321 - 360 minutes post meal challenge[a] in 11 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
1	0.99	1.01	0.02
2	0.92	0.92	0.00
3	0.87	0.80	-0.07
4	0.92	0.98	0.06
5			
6			
7	0.86	0.89	0.03
8	1.20	1.02	-0.18
9	1.06	0.90	-0.16
10	1.05	0.88	-0.17
11	0.92	0.95	0.03
12	1.14	0.98	-0.16
13	0.88	0.73	-0.15

n = 11
mean = -0.07
SEM = 0.03
p < 0.025

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 35. Difference in carbohydrate oxidation between the HC diet and the HF diet while fasting in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	grams	grams	grams
1	191.91	147.09	-44.82
2	172.84	121.03	-51.81
3	164.78	167.42	2.64
4	111.72	73.48	-38.24
5	44.59	188.42	143.83
6			
7	85.36	-35.08	-120.44
8	84.39	70.34	-14.05
9	197.97	99.10	-98.87
10	106.34	120.83	14.49
11	164.84	-15.58	-180.42
12	145.06	48.50	-96.46
13	148.97	-35.84	-184.81

n = 12
mean = -55.75
SEM = 26.60
p < 0.05

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = comparison of differences in the direction of HF minus HC

Table 36. Difference in carbohydrate oxidation between the HC diet and the HF diet 1 - 40 minutes post meal challenge[a] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
	grams	grams	grams
1	167.17	216.63	49.46
2	184.86	132.37	-52.49
3	160.11	105.41	-54.70
4	130.01	169.10	39.09
5	97.21	197.61	100.40
6			
7	271.21	63.06	-208.15
8	247.39	189.38	-58.01
9	230.15	114.55	-115.60
10	182.16	173.76	-8.40
11	265.02	54.78	-210.24
12	238.12	107.88	-130.24
13	185.67	62.41	-123.26

n = 12
mean = -64.34
SEM = 28.42
p < 0.025

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 37. Carbohydrate oxidation difference between the HC diet and the HF diet 81 - 120 minutes post meal challenge[a] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
	grams	grams	grams
1	336.63	276.13	-60.5
2	320.23	252.67	-67.56
3	210.77	167.13	-43.64
4	269.34	306.14	36.80
5	297.31	294.91	-2.40
6			
7	537.61	96.89	-440.72
8	263.14	147.05	-116.09
9	339.55	220.67	-118.88
10	347.84	221.97	-125.87
11	318.42	153.67	-164.75
12	475.99	210.71	-265.28
13	487.04	161.68	-325.36

n = 12
mean =-141.19
SEM = 40.20
p < 0.005

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 38. Difference in carbohydrate oxidation between the HC diet and the HF diet 161 - 200 minutes post meal challenge[a] healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
	grams	grams	grams
1	254.31	229.51	-24.80
2	232.23	176.69	-55.54
3	163.20	121.99	-41.21
4	227.42	242.87	15.45
5	222.47	165.05	-57.42
6			
7	124.93	157.00	32.07
8	277.27	227.64	-49.63
9	270.82	172.58	-98.24
10	343.24	157.95	-185.29
11	174.56	201.79	27.23
12	325.05	218.09	-106.96
13			

n = 11
mean = -49.49
SEM = 19.46
p < 0.025

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 39. Difference in carbohydrate oxidation between the HC diet and the HF diet 241 - 280 minutes post meal challenge[a] in 11 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
	grams	grams	grams
1	228.37	225.70	-2.67
2	160.16	168.36	8.20
3	133.72	75.90	-57.82
4	165.80	205.39	39.59
5			
6			
7	124.93	157.00	32.07
8	277.27	227.64	-49.63
9	270.82	172.58	-98.24
10	343.24	157.95	-185.29
11	174.56	201.79	27.23
12	325.05	218.08	-106.96
13	174.09	3.53	-170.56

n = 11
mean = -51.28
SEM = 22.7
p < 0.025

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 40. Difference in carbohydrate oxidation between the HC diet and the HF diet 321 - 360 minutes post meal challenge[a] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
	grams	grams	grams
1	315.43	271.50	-43.93
2	307.95	247.87	-60.08
3	283.01	218.39	-64.62
4	230.19	277.61	47.42
5	231.15	288.24	57.09
6			
7	439.50	123.85	-315.65
8	324.63	142.85	-181.78
9	372.67	236.21	-136.46
10	345.33	283.22	-62.11
11	317.21	109.74	-207.47
12	380.98	180.73	-200.25
13	388.21	216.06	-172.15

n = 12
mean =-111.67
SEM = 31.80
p < 0.005

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 41. Difference in fat oxidation between the HC diet and the HF diet while fasting in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	grams	grams	grams
1	2.69	17.44	14.75
2	10.04	28.75	18.71
3	14.46	12.16	-2.30
4	48.69	66.03	17.34
5	87.07	21.63	-65.44
6			
7	62.77	113.41	50.64
8	23.50	52.59	29.09
9	2.78	60.08	57.30
10	56.97	45.26	-11.71
11	21.88	108.44	86.56
12	27.97	74.97	47.0
13	51.90	119.08	67.18

n = 12
mean = 25.78
SEM = 11.77
$p < 0.05$

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = comparison of differences in the direction of HF minus HC

Table 42. Difference in fat oxidation between the HC diet and the HF diet 1 - 40 minutes post meal challenge[a] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
	grams	grams	grams
1	22.61	6.92	-15.69
2	8.36	33.84	25.48
3	36.65	59.92	23.27
4	55.15	30.77	-24.38
5	83.22	31.34	-51.88
6			
7	-9.16	110.67	119.83
8	-32.59	12.55	45.14
9	-8.82	64.59	73.41
10	41.37	27.59	-13.78
11	-4.73	100.24	104.97
12	3.22	51.37	48.15
13	32.78	87.73	54.95

n = 12
mean = 32.46
SEM = 14.37
p < 0.025

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 43. Difference in fat oxidation between the HC diet and the HF diet 81 - 120 minutes post meal challenge[a] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
	grams	grams	grams
1	-10.45	-21.38	-10.93
2	-35.42	-7.00	28.42
3	-15.24	14.12	29.36
4	10.92	-20.02	-30.94
5	24.41	-12.25	-36.66
6			
7	-89.99	57.90	147.89
8	-61.72	20.54	82.26
9	-64.95	14.54	79.49
10	-25.80	-20.44	5.36
11	-28.08	50.45	78.53
12	-69.61	15.94	85.55
13	-57.32	26.18	83.50

n = 12
mean = 45.15
SEM = 16.30
p < 0.01

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = a liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 44. Difference in fat oxidation between the HC diet and the HF diet 161 - 200 minutes post meal challenge[a] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
	grams	grams	grams
1	-38.64	-27.99	10.65
2	-33.99	-25.35	54.34
3	1.49	27.07	25.58
4	-14.34	-43.60	-29.26
5	-7.58	-21.54	-13.96
6			
7	-149.30	63.53	212.83
8	-60.54	19.79	80.33
9	-66.12	17.04	83.16
10	-33.36	10.07	43.43
11	-32.75	36.79	69.54
12	-112.26	5.40	117.66
13	-100.72	49.16	149.88

n = 12
mean = 63.21
SEM = 20.53
p < 0.01

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 45. Difference in fat oxidation between the HC diet and the HF diet 241 - 280 minutes post meal challenge[a] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
	grams	grams	grams
1	-22.33	-19.76	2.57
2	-18.86	7.59	26.45
3	25.99	54.12	28.13
4	-8.28	-25.32	-17.04
5	-7.58	-18.96	-11.38
6			
7	-96.88	59.63	156.51
8	-75.33	-8.45	66.88
9	-62.44	34.53	96.97
10	-56.55	16.65	73.20
11	-27.67	8.21	35.88
12	-121.70	8.73	130.43
13	-78.97	52.34	131.31

n = 12
mean = 63.54
SEM = 16.59
p < 0.005

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 46. Difference in fat oxidation between the HC diet and the HF diet 321-360 minutes post meal challenge[a] in 11 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[b]
	grams	grams	grams
1	-4.10	-18.58	-14.48
2	16.60	13.45	-3.15
3	33.33	72.34	39.01
4	14.45	-7.77	-22.22
5			
6			
7	42.83	29.47	-13.36
8	-61.09	-18.73	42.36
9	-36.12	25.63	61.75
10	-39.13	31.41	70.54
11	14.37	-3.75	-18.12
12	-58.08	-10.62	47.46
13	37.84	116.52	78.68

n = 11
mean = 24.41
SEM = 11.77
p < 0.05

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparisons of differences in the direction of HF minus HC

Table 47. Summary of the differences in fat oxidation while fasting and for five 40-minute DIT[a] periods between the HC and the HF diet in 12 healthy, never-obese, postmenopausal, Caucasian females

Period after Meal	Mean Difference	SEM	P
Minutes	grams		
Fasting	25.78	11.77	< .05
1 (1 - 40)	32.46	14.37	< .025
2 (81 - 120)	45.15	16.30	< .01
3 (161 - 200)	63.21	20.53	< .01
4 (241 - 280)	63.54	16.59	< .005
5 (321 - 360)	24.41	11.77	< .05

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = liquid meal of same composition as the HC or HF, respectively, at 14.3 kcal/kg of fat-free mass

b = comparison of differences in the direction of HF minus HC

Table 48. Difference in protein oxidation between the HC diet and the HF diet after 22 days each at weight maintenance energy intake in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	grams	grams	grams
1	31.13	51.13	20.00
2	43.38	42.19	8.81
3	41.00	48.19	7.19
4	49.06	46.19	-2.87
5	45.75	37.94	-7.81
6			
7	46.94	49.25	2.31
8	40.06	51.75	11.69
9	49.56	45.31	-4.25
10	55.75	69.13	13.38
11	44.88	68.56	23.68
12	42.75	61.06	18.31
13	47.06	60.19	13.13

n = 12
mean = 8.63
SEM = 2.90-
p < 0.01

HC = after high carbohydrate-low fat diet

HF = after high fat-low carbohydrate diet

a = comparison of differences in the direction of HF minus HC

Table 49. Difference in protein balance between the HC diet and the HF diet after 22 days each at weight maintenance energy intake, respectively in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	grams	grams	grams
1	23.5	3.3	-20.2
2	11.2	2.2	-9.0
3	16.4	8.9	-7.5
4	5.5	8.1	2.6
5	8.8	16.5	7.7
6			
7	2.1	-0.2	-2.3
8	17.3	7.8	-9.5
9	16.2	19.8	3.6
10	1.6	-9.6	-11.2
11	9.7	-14.3	-24.0
12	11.8	-6.7	-18.5
13	10.3	-3.1	-13.4

n = 12
mean = -8.5
SEM = 2.9
p < 0.01

HC = after high carbohydrate-low fat diet

HF = after high fat-low carbohydrate diet

a = comparison of differences in the direction of HF minus HC

Table 50. Difference in fasting glucose levels before and after 22 days on the HC diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	mg/dl	mg/dl	mg/dl
1	73.3	65.9	-7.4
2	81.7	80.8	-0.9
3	96.1	76.3	-19.8
4	92.7	81.8	-10.9
5	84.4	68.0	-16.4
6	89.3	85.7	-3.6
7	100.0	81.2	-18.8
8	73.8	102.4	28.6
9	79.0	97.9	18.9
10	77.5	89.9	12.4
11			
12	60.0	70.9	10.9
13	73.1	68.5	-4.6

n = 12
mean = 1.00
SEM = 4.50
p < 0.10

HC = high carbohydrate-low fat diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 51. Difference in fasting glucose levels before and after 22 days on the HF diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	mg/dl	mg/dl	mg/dl
1	73.2	78.7	5.5
2	75.2	77.8	2.6
3	65.3	78.7	13.4
4	89.5	93.3	3.8
5	84.9	80.5	-4.4
6	86.6	87.4	0.8
7	81.8	101.8	20.0
8	67.4	108.7	41.3
9	72.3	78.0	5.7
10	55.2	84.5	29.3
11			
12	62.6	70.7	8.1
13	66.3	70.8	4.5

n = 12
mean = 10.9
SEM = 3.6
p < 0.025

HF = high fat-low carbohydrate diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 52. Difference in fasting insulin levels before and after 22 days on the HC diet in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	uU/ml	uU/ml	uU/ml
1	8.3	8.4	0.1
2	9.0	7.8	-1.2
3			
4	10.0	11.7	1.7
5			
6	6.1	7.9	1.8
7	4.5	14.0	9.5
8.	9.1	17.9	8.8
9	1.5	3.7	2.2
10	7.0	10.5	3.5
11			
12	11.5	2.2	-9.3
13	4.3	0.8	-3.5

n = 10
mean = 1.4
SEM = 1.7
p > 0.10

HC = high carbohydrate-low fat diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 53. Difference in fasting insulin levels before and after 22 days on the HF diet in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	uU/Ml	uU/ml	uU/ml
1	12.0	9.1	-2.9
2	6.2	8.6	2.4
3			
4	7.9	7.4	-0.5
5			
6	7.3	5.4	-1.9
7	9.0	9.0	0.0
8	8.0	13.9	5.9
9	7.2	2.7	-4.5
10	0.7	4.7	4.0
11			
12	7.4	9.8	2.4
13	1.3	3.8	2.5

n = 10
mean = 0.74
SEM = 1.00
p > 0.10

HF = high fat-low carbohydrate diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 54. Difference in fasting glucagon levels before and after 22 days on the HC diet in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	pg/ml	pg/ml	pg/ml
1			
2	307	107	-200
3	472	300	-172
4	215	170	-45
5			
6	362	325	-37
7	254	190	-64
8	154	57	-97
9	504	308	-204
10	1089	850	-239
11			
12	149	374	225
13	78	43	-35

n = 10
mean = 86.80
SEM = 42.40
p < 0.05

HC = high carbohydrate-low fat diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 55. Difference in fasting glucagon levels before and after 22 days on the HF diet in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	pg/ml	pg/ml	pg/ml
1			
2	135	124	-11
3	171	277	106
4	168	127	-41
5			
6	336	320	-16
7	218	248	30
8	228	98	-130
9	499	390	-109
10	607	851	244
11			
12	80	58	-22
13	83	84	1

n = 10
mean = 5.2
SEM = 33.8
p > 0.10

HF = high fat-low carbohydrate diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 56. Difference in fasting free fatty acids before and after 22 days on the HC diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	meq/l	meq/l	meq/l
1	353.5	233.0	-120.5
2	624.4	487.4	-137.0
3	300.8	962.2	661.4
4	218.4	529.4	311.0
5	126.6	555.8	429.2
6	102.2	393.2	291.0
7	202.2	355.5	143.3
8	207.4	524.0	316.6
9	203.0	322.0	119.0
10	243.8	306.0	62.2
11			
12	453.3	501.3	48.0
13	312.5	393.8	81.3

n = 12
mean = 183.8
SEM = 66.21
p < 0.01

HC = high carbohydrate-low fat diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 57. Difference in fasting free fatty acids before and after 22 days on the HF diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	meq/l	meq/l	meq/l
1	473.5	531.2	57.7
2	319.0	616.9	297.9
3	526.2	672.3	146.1
4	227.4	583.6	356.2
5	169.8	725.5	555.7
6	277.1	322.9	45.8
7	747.5	294.1	463.4
8	367.9	323.2	-44.7
9	316.6	643.7	327.1
10	470.9	105.9	-365.0
11			
12	421.4	456.5	30.1
13	246.3	267.5	21.2

n = 12
mean = 80.40
SEM = 84.00
p > 0.10

HF = high fat-low carbohydrate diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 58. Difference in fasting total cholesterol before and after 22 days on the HC diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	mg/dl	mg/dl	mg/dl
1	193	176	-17
2	228	186	-42
3	274	269	-5
4	330	318	-12
5	310	258	-42
6	251	253	2
7	252	217	35
8	238	269	58
9	271	288	17
10	253	248	-5
11			
12	282	294	12
13	342	303	-39

n = 12
mean = -9.8
SEM = 8.8
p > 0.10

HC = high carbohydrate-low fat diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 59. Difference in fasting total cholesterol before and after 22 days on the HF diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	mg/dl	mg/dl	mg/dl
1	194	245	51
2	204	226	22
3	229	307	78
4	390	275	-115
5	252	277	25
6	271	253	-18
7	231	287	56
8	235	235	0
9	251	243	-8
10	187	243	56
11			
12	257	296	39
13	247	357	10

n = 12
mean = 16.3
SEM = 14.52
p > 0.10

HF = high fat-low carbohydrate diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 60. Difference in fasting triglyceride levels before and after 22 days on the HC diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	mg/dl	mg/dl	mg/dl
1	62	58	-4
2	57	70	13
3	131	59	-72
4	132	152	20
5	105	77	-29
6	117	94	-23
7	117	68	-49
8	56	95	39
9	84	58	-26
10	79	63	-16
11			
12	78	125	47
13	188	98	-90

n = 12
mean = -16
SEM = 11
p = 0.09

HC = high carbohydrate-low fat diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 61. Difference in fasting triglyceride levels before and after 22 days on the HF diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	mg/dl	mg/dl	mg/dl
1	57	67	10
2	49	42	-7
3	63	56	-7
4	200	85	-115
5	61	58	-4
6	119	112	-7
7	67	81	14
8	136	11	-125
9	123	36	-87
10	165	51	-114
11			
12	100	103	3
13	49	86	37

n = 12
mean = -34
SEM = 17
$p < 0.05$

HF = high fat-low carbohydrate diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 62. Difference in T_4 levels before and after 22 days on the HC diet in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCES
	meq/dl	meq/dl	meq/dl
1			
2			
3			
4	7.0	6.4	-0.6
5	5.2	5.1	-0.1
6	5.7	6.6	0.9
7	6.6	6.7	0.1
8	6.2	6.4	0.2
9	5.4	5.9	0.5
10	7.2	7.0	-0.2
11	7.5	7.4	-0.1
12	5.6	6.0	0.4
13	5.7	6.1	0.4

n = 10
mean = 0.15
SEM = 0.13
p > 0.10

HC = high carbohydrate-low fat diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 63. Difference in T_4 levels before and after 22 days on the HF diet in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	meq/dl	meq/dl	meq/dl
1			
2			
3			
4	6.5	6.1	-0.4
5	6.3	5.8	-0.5
6	6.1	6.5	0.4
7	7.6	7.6	0.0
8	6.4	6.1	-0.3
9	5.4	5.7	0.3
10	6.5	6.4	-0.1
11	7.8	7.9	0.1
12	5.6	5.5	-0.1
13	5.6	5.7	0.1

n = 10
mean = -0.05
SEM = 0.09
p > 0.10

HF = high fat-low carbohydrate diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = a comparison of differences in the direction of "after" minus "before"

Table 64. Difference in T_3 levels before and after 22 days in the HC diet in 8 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	meq/dl	meq/dl	meq/dl
1			
2			
3			
4			
5	84	95	11
6	66	82	16
7			
8	75	58	-17
9	78	82	4
10	84	65	-19
11	111	103	-8
12	85	91	6
13	92	71	-21

n = 8
mean = 0.4
SEM = 6.3
p > 0.10

HF = high fat-low carbohydrate diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 65. Difference in T_3 levels before and after 22 days on the HF diet in 8 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	BEFORE	AFTER	DIFFERENCE[a]
	meq/dl	meq/dl	meq/dl
1			
2			
3			
4			
5	81	69	-12
6	46	78	32
7			
8	78	70	-8
9	76	67	-9
10	69	67	-2
11	120	102	-18
12	80	76	-4
13	62	86	24

n = 8
mean = 0.4
SEM = 6.3
p > 0.10

HF = high fat-low carbohydrate diet which followed at least 7 days on the standard Western diet isocalorically and isonitrogenously at maintenance energy intake

a = comparison of differences in the direction of "after" minus "before"

Table 66. Difference in fasting glucose levels between the HC diet and the HF diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	mg/dl	mg/dl	mg/dl
1	65.9	78.7	12.8
2	80.8	77.8	-3.0
3	76.3	78.7	2.4
4	81.8	93.3	11.5
5	68.0	80.5	12.5
6	85.7	87.4	1.7
7	81.2	101.8	20.6
8	102.4	108.7	6.3
9	97.9	78.0	-19.9
10	89.9	84.5	-5.4
11			
12	70.9	70.7	-0.2
13	68.5	70.8	2.3

n = 12
mean = 3.5
SEM = 3.3
p > 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = comparison of differences in the direction of HF minus HC

Table 67. Difference in fasting insulin levels between the HC diet and the HF diet in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	uU/ml	uU/ml	uU/ml
1	8.4	9.1	0.7
2	7.8	8.6	0.8
3			
4	11.7	7.4	-4.3
5			
6	7.9	5.4	-2.5
7	14.0	9.0	-5.0
8	17.9	13.9	-4.0
9	3.7	2.7	-1.0
10	10.5	4.7	-5.8
11			
12	2.2	9.8	7.6
13	0.8	3.8	3.0

n = 10
mean = -1.0
SEM = 1.3
p > 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = comparison of differences in the direction of HF minus HC

Table 68. Difference in fasting glucagon levels between the HC and the HF diet in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	pg/ml	pg/ml	pg/ml
1			
2	107	124	17
3	300	277	-23
4	170	127	-43
5			
6	325	320	-5
7	190	248	58
8	57	98	41
9	308	390	82
10	850	851	1
11			
12	374	58	-316
13	43	84	41

n = 10
mean = -15
SEM = 36
p > 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = comparison of differences in the direction of HF minus HC

Table 69. Difference in fasting free fatty acids between the HC diet and the HF diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	meq/l	meq/l	meq/l
1	233.0	531.2	298.2
2	487.4	616.9	129.5
3	962.2	672.3	-289.9
4	529.4	583.6	54.2
5	555.8	725.5	169.7
6	393.2	322.9	-70.3
7	355.5	284.1	-71.4
8	524.0	323.2	-200.8
9	322.0	643.7	321.7
10	306.0	105.9	-200.1
11			
12	501.3	451.5	-49.8
13	393.8	267.5	-126.3

n = 12
mean = -2.90
SEM = 57.30
p > 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = comparison of differences in the direction of HF minus HC

Table 70. Difference in fasting total cholesterol levels between the HC diet and HF diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	mg/dl	mg/dl	mg/dl
1	176	245	69
2	186	226	40
3	269	307	38
4	318	275	-43
5	258	277	19
6	253	253	0
7	217	287	70
8	269	235	-34
9	288	243	-45
10	248	243	-5
11			
12	294	296	2
13	303	257	54

n = 12
mean = 14.00
SEM = 12.00
p > 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = comparison of differences in the direction of HF minus HC

Table 71. Difference in fasting triglyceride levels between the HC diet and the HF diet in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	mg/dl	mg/dl	mg/dl
1	58	67	9
2	70	42	-28
3	59	56	-3
4	152	85	-67
5	77	58	-19
6	94	112	18
7	68	81	13
8	95	11	-84
9	58	36	-22
10	63	51	-14
11			
12	125	103	-21
13	98	86	-12

n = 12
mean = -19.00
SEM = 9.00
p < 0.05

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = comparison of differences in the direction of HF minus HC

Table 72. Difference in fasting T_4 levels between the HC diet and the HF diet in 10 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	meq/dl	meq/dl	meq/dl
1			
2			
3			
4	6.4	6.1	-0.3
5	5.1	5.8	0.7
6	6.6	6.5	-0.1
7	6.7	7.6	0.9
8	6.4	6.1	-0.3
9	5.9	5.7	-0.2
10	7.0	6.4	-0.6
11	7.4	7.9	0.5
12	6.0	5.5	-0.5
13	6.1	5.7	-0.4

n = 10
mean = -0.03
SEM = 0.17
p < 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = comparison of differences in the direction of HF minus HC

Table 73. Difference in fasting T_3 levels between the HC diet and the HF diet in 8 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[a]
	meq/dl	meq/dl	meq/dl
1			
2			
3			
4			
5	95	69	-26
6	82	78	-4
7			
8	58	70	12
9	82	67	-15
10	65	67	2
11	103	102	-1
12	91	76	-15
13	71	86	15

n = 8
mean = -4.00
SEM = 5.00
p < 0.10

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = comparison of differences in the direction of HF minus HC

Table 74. Difference in the change in glucose concentration[a] between the HC diet and the HF diet 40 minutes (period 1) after a challenge test meal[b] in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCES[c]
	mg/dl	mg/dl	mg/dl
1	-1.7	3.0	4.7
2	35.8	19.2	-16.6
3	21.7	32.1	10.4
4	90.9	15.8	-75.1
5	40.3	22.0	-18.3
6	66.5	45.6	-20.9
7	47.5	28.2	-19.3
8	46.4	24.0	-22.4
9	109.1	35.7	-73.4
10	60.2	10.7	-49.5
11	59.1	54.9	-4.2
12	28.1	25.2	-2.9
13	40.4	23.0	-17.4

n = 13
mean = -23.50000
SEM = 7.50000
p = 0.00425

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the glucose value at 40 minutes minus the fasting baseline glucose value. The negative value for subject number one represents a value which was less than the fasting baseline glucose value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

c = comparison in the direction of HF minus HC

Table 75. Difference in the change in glucose concentration[a] between the HC diet and the HF diet 120 minutes (period 2) after a challenge test meal[b] in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	mg/dl	mg/dl	mg/dl
1	-8.5	-10.4	-1.9
2	1.7	-4.2	-5.9
3	36.5	41.4	4.9
4	52.9	-4.7	-57.6
5	73.7	7.4	-66.3
6	63.9	13.0	-50.9
7	44.6	59.1	14.5
8	24.2	2.5	-21.7
9	79.9	61.6	-18.3
10	78.5	-12.1	-90.6
11	23.8	1.9	-21.9
12	9.8	4.1	-5.7
13	10.0	25.0	15.0

n = 13
mean = -23.5
SEM = 9.2
p = 0.01

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the glucose value at 120 minutes minus the fasting baseline glucose value. A negative value for HC or HF represents a value which was less than the fasting baseline glucose value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 76. Difference in the change in glucose concentration[a] between the HC diet and the HF diet 200 minutes (period 3) after a challenge test meal[b] in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	mg/dl	mg/dl	mg/dl
1	-11.5	-2.0	9.5
2	-5.5	6.9	12.4
3	5.0	6.7	1.7
4	26.5	-13.3	-39.8
5	30.0	18.9	-11.1
6	24.6	-14.9	-39.5
7	9.6	26.8	17.2
8	-2.8	37.8	40.6
9	6.4	5.2	-1.2
10	55.9	24.4	-31.5
11	9.9	18.3	8.4
12	14.3	-6.5	-20.8
13	24.9	0.5	-24.4

n = 13
mean = -6.00
SEM = 6.70
p = 0.19

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the glucose value at 200 minutes minus the fasting baseline glucose value. A negative value for HC or HF represents a value which was less than the fasting baseline glucose value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 77. Difference in the change in glucose concentration[a] between the HC diet and the HF diet 280 minutes (period 4) after a challenge test meal[b] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	mg/dl	mg/dl	mg/dl
1	-8.6	2.2	10.8
2			
3	4.1	-2.1	-6.2
4	0.5	-12.8	-13.3
5	-21.2	3.6	24.8
6	-2.8	-24.5	-21.7
7	-19.2	23.6	42.8
8	10.4	0.1	-10.3
9	-4.9	4.4	9.3
10	6.2	2.0	-4.2
11	-13.8	0.4	14.2
12	-2.5	-1.3	1.2
13	9.2	0.1	-9.1

n = 12
mean = 3.20
SEM = 5.20
p = 0.28

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the glucose value at 280 minutes minus the fasting baseline glucose value. A negative value for HC or HF represents a value which was less than the fasting baseline glucose value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 78. Difference in the change in glucose concentration[a] between the HC diet and the HF diet 360 minutes (period 5) after a challenge test meal[b] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	mg/dl	mg/dl	mg/dl
1	-2.1	0.0	2.1
2	-6.1	0.7	6.8
3	1.1	-1.5	-2.6
4	-2.6	-11.6	-9.0
5			
6	-7.7	-4.0	3.7
7	-4.3	-21.5	-17.2
8	0.5	-0.6	-0.11
9	8.1	2.2	-5.9
10	5.1	3.6	-1.5
11	-10.2	-1.2	9.0
12	-4.1	0.4	4.5
13	2.3	0.9	-1.4

n = 12
mean = -0.98
SEM = 2.1
p = 0.33

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the glucose value at 360 minutes minus the fasting baseline glucose value. A negative value for HC or HF represents a value which was less than the fasting baseline glucose value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 79. Difference in the change in insulin concentration[a] between the HC diet and the HF diet 40 minutes (period 1) after a challenge test meal[b] in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	uU/ml	uU/ml	uU/ml
1	23.8	51.2	27.4
2	54.5	21.3	-33.2
3	29.4	23.3	-6.1
4	79.1	50.2	-28.9
5	37.8	40.1	2.3
6	22.7	21.8	-0.9
7	37.1	55.8	18.7
8	52.7	65.4	12.7
9	63.3	35.7	-27.6
10	29.2	54.8	25.6
11	107.0	45.9	-61.1
12	54.4	49.9	-5.5
13	69.2	26.8	-42.4

n = 13
mean = -9.2
SEM = 7.7
p = 0.13

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the insulin value at 40 minutes minus the fasting baseline insulin value. A negative value for HC or HF represents a value which was less than the fasting baseline insulin value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 80. Difference in the change in insulin concentration[a] between the HC diet and the HF diet 120 minutes (period 2) after a challenge test meal[b] in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	uU/ml	uU/ml	uU/ml
1	69.3	6.4	-62.9
2	31.1	10.4	-20.7
3	18.2	14.7	-3.5
4	72.1	11.9	-60.2
5	59.9	10.8	-49.1
6	29.1	16.8	-12.3
7	70.0	11.3	-58.7
8	49.7	2.1	-47.6
9	98.7	35.9	-62.8
10	24.3	-1.4	-25.7
11	37.7	3.9	-33.8
12	34.8	2.9	-31.9
13	23.8	5.4	-18.4

n = 13
mean = -37.5
SEM = 5.7
p < 0.0001

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the insulin value at 120 minutes minus the fasting baseline insulin value. A negative value for HC or HF represents a value which was less than the fasting baseline insulin value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectively, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 81. Difference in the change in insulin concentration[a] between the HC diet and the HF diet 200 minutes (period 3) after a challenge test meal[b] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HD	HF	DIFFERENCE[c]
	uU/ml	uU/ml	uU/ml
1	2.4	9.6	7.2
2	27.5	-3.1	-30.6
3	-4.7	-2.2	2.5
4	10.1	7.2	-2.9
5	8.6	20.9	12.3
6	15.6	4.3	-11.3
7	2.5	3.8	1.3
8	31.5	21.6	-9.9
9	8.0	14.0	6.0
10			
11	17.5	4.3	-13.2
12	11.6	1.4	-10.2
13	15.5	-1.2	-16.7

n = 12
mean = -5.50
SEM = 3.50
p = 0.07

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the insulin value at 200 miutes minus the fasting baseline insulin value. A negative value for HC or HF represents a value which was less than the fasting baseline insulin value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 82. Difference in the change in insulin concentration[a] between the HC diet and the HF diet 280 minutes (period 4) after a challenge test meal[b] in 13 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	uU/ml	uU/ml	uU/ml
1	9.2	-0.2	-9.4
2	-0.3	-2.8	-2.5
3	-0.3	-0.6	-0.3
4	2.6	3.8	1.2
5	-4.6	0.5	5.1
6	5.0	1.5	-3.5
7	-3.7	-2.5	1.2
8	9.2	9.3	0.1
9	3.0	1.7	-1.3
10	25.8	13.3	-12.5
11	9.5	4.0	-5.5
12	2.0	-3.0	-5.0
13	2.0	1.8	-0.2

n = 13
mean = -2.50
SEM = 1.30
P < 0.04

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the insulin value at 280 minutes minus the fasting baseline insulin value. A negative value for HC or HF represents a value which was less than the fasting baseline insulin value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 83. Difference in the change in insulin concentration[a] between the HC diet and the HF diet 360 minutes (period 5) after a challenge test meal[b] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	uU/ml	uU/ml	uU/ml
1	-1.2	1.9	3.2
2	3.0	-3.5	-6.5
3	-5.2	-1.9	3.3
4	-5.2	5.3	10.5
5			
6	0.0	5.8	5.8
7	-10.5	-2.5	8.0
8	-9.4	15.9	25.3
9	-0.1	1.2	1.3
10	-1.8	18.6	20.6
11	2.6	0.9	-1.7
12	-0.1	-5.6	-5.5
13	2.3	3.6	1.3

n = 12
mean = 5.50
SEM = 2.80
p = 0.04

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the insulin value at 360 minutes minus the fasting baseline insulin value. A negative value for HC or HF represents a value which was less than the fasting baseline insulin value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 84. Difference in the change in glucagon concentration[a] between the HC diet and the HF diet 40 minutes (period 1) after a challenge test meal[b] in 11 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	pb/ml	pg/ml	pg/ml
1			
2	151	140	-11
3	122	-42	-164
4	-25	7	32
5	2	219	217
6	-5	23	28
7	14	-3	-17
8	26	10	-26
9	-28	168	196
10	-194	-79	115
11			
12	225	-6	-231
13	67	-15	-82

n = 11
mean = -5.20
SEM = 41.4
p = 0.45

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the glucagon value at 40 minutes minus the fasting baseline glucagon value. A negative value for HC or HF represents a value which was less than the fasting baseline glucagon value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 85. Difference in the change in glucagon concentration[a] between the HC diet and the HF diet 120 minutes (period 2) after a challenge test meal[b] in 11 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	pg/ml	pg/ml	pg/ml
1			
2	79	89	10
3	58	-36	-94
4	-2	52	54
5	24	55	31
6	-35	127	162
7	31	-25	-56
8	32	29	-3
9	-11	-42	-31
10	-13	-181	-168
11			
12	-33	55	88
13	4	16	12

n = 11
mean = 0.55
SEM = 26.80
p = 0.49

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the glucagon value at 120 minutes minus the fasting baseline glucagon value. A negative value for HC or HF represents a value which was less than the fasting baseline glucagon value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 86. Difference in the change in glucagon concentration[a] between the HC diet and the HF diet 200 minutes (period 3) after a challenge test meal[b] in 9 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	pg/ml	pg/ml	pg/ml
1			
2	66	73	7
3	47	117	70
4	-33	66	99
5	-12	82	94
6			
7	46	33	-13
8	30	-4	-34
9	42	147	105
10	-24	-98	-74
11			
12			
13	14	-19	-33

n = 9
mean = 24.50
SEM = 22.70
p = 0.16

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the glucagon value at 200 minutes minus the fasting baseline glucagon value. A negative value for HC or HF represents a value which was less than the fasting baseline glucagon value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 87. Difference in the change in glucagon concentration[a] between the HC diet and the HF diet 280 minutes (period 4) after a challenge test meal[b] in 9 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	pg/ml	pg/ml	pg/ml
1			
2	87	60	-27
3	-78	70	148
4	-17	51	68
5	12	102	90
6	168	55	-113
7	45	9	-36
8	20	24	4
9	167	59	-180
10			
11			
12			
13	35	-23	-58

n = 9
mean = -3.60
SEM = 29.90
p = 0.45

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the glucagon value at 280 minutes minus the fasting baseline glucagon value. A negative value for HC or HF represents a value which was less than the fasting baseline glucagon value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 88. Difference in the change in glucagon concentration[a] between the HC diet and the HF diet 360 minutes (period 5) after a challenge test meal[b] in 9 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	pg/ml	pg/ml	pg/ml
1			
2	34	75	41
3	-45	71	116
4	0	52	52
5			
6	10	37	27
7	27	-38	-65
8	49	1	-48
9	26	-49	-75
10	-6	-369	-363
11			
12			
13	40	-48	-88

n = 9
mean = -38.20
SEM = 52.10
p = 0.24

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the glucagon value at 360 miutes minus the fasting baseline glucagon value. A negative value for HC or HF represents a value which was less than the fasting baseline glucagon value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 89. Difference in the change in free fatty acid concentration[a] between the HC diet and the HF diet 40 minutes (period 1) after a challenge test meal[b] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	meq/l	meq/l	meq/l
1	29.9	-338.0	-367.9
2	-126.9	-354.1	-227.2
3	58.4	-108.0	-166.4
4	-231.2	-153.4	77.8
5	-187.7	-341.5	-153.8
6	-315.4	-278.7	36.7
7	-112.7	-150.8	-38.1
8	-427.0	-125.1	301.9
9	-230.4	-538.8	-308.0
10	37.0	43.6	6.6
11			
12	-322.7	-169.7	153.0
13	105.8	-89.6	-195.4

n = 12
mean = -73.40
SEM = 57.10
p = 0.11

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the free fatty acid concentration value at 40 minutes minus the fasting baseline free fatty acid concentration value. A negative value for HC or HF represents a value which was less than the fasting baseline free fatty acid value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 90. Difference in the change in free fatty acid concentration[a] between the HC diet and the HF diet 120 minutes (period 2) after a challenge test meal[b] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	meq/l	meq/l	meq/l
1	-233.0	-365.7	-132.7
2	-453.9	-558.7	-104.8
3	-482.4	-576.5	-94.1
4	-519.1	-461.0	58.1
5	-535.5	-533.1	3.4
6	-373.6	-291.1	82.5
7	-315.4	-213.6	101.8
8	-580.0	-205.9	302.1
9	-322.0	-545.8	-223.8
10	-282.0	-55.3	226.7
11			
12	-412.4	-342.9	69.5
13	-320.9	-180.4	140.5

n = 13
mean = 35.80
SEM = 44.40
p = 0.22

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the free fatty acid concentration value at 120 minutes minus the fasting baseline free fatty acid concentration value. A negative value for HC or HF represents a value which was less than the fasting baseline free fatty acid value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 91. Difference in the change in free fatty acid concentration[a] between the HC diet and the HF diet 200 minutes (period 3) after a challenge test meal[b] in 12 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	meq/l	meq/l	meq/l
1	-233.0	-307.7	-74.7
2	-487.4	-574.6	-87.2
3	-416.3	-212.5	203.8
4	-529.4	-332.4	197.0
5	-537.0	-195.0	342.1
6	-381.3	-110.5	270.8
7	-308.5	-127.9	180.5
8	-524.0	-74.6	449.4
9	-322.0	-551.6	-229.9
10	-306.0	28.4	334.4
11			
12	-433.3	-53.4	379.9
13	-257.3	-57.2	200.1

n = 12
mean = 180.60
SEM = 60.10
p = 0.006

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the free fatty acid concentration value at 200 minutes minus the fasting baseline free fatty acid concentration value. A negative value for HC or HF represents a value which was less than the fasting baseline free fatty acid value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 92. Difference in the change in free fatty acid concentration[a] between the HC diet and the HF diet 280 minutes (period 4) after a challenge test meal[b] in 9 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	meq/l	meq/l	meq/l
1	-233.0	-272.4	-39.4
2			
3	-314.6	652.7	957.3
4			
5	-436.6	70.3	506.9
6	-310.9	145.0	455.9
7	-155.6	249.1	404.7
8			
9	-263.4	-262.9	-0.5
10	-306.0	99.4	405.4
11			
12	-430.3	-151.8	278.5
13	-199.0	49.5	248.5

n = 9
mean = 357.5
SEM = 98.6
p = 0.003

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the free fatty acid concentration value at 280 minutes minus the fasting baseline free fatty acid concentration value. A negative value for HC or HF represents a value which was less than the fasting baseline free fatty acid value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

Table 93. Difference in the change in free fatty acid concentration[a] between the HC diet and the HF diet 360 minutes (period 5) after a challenge test meal[b] in 11 healthy, never-obese, postmenopausal, Caucasian females

SUBJECT	HC	HF	DIFFERENCE[c]
	meq/l	meq/l	meq/l
1	-104.1	-111.9	-7.8
2	-206.5	-82.3	-124.2
3	-209.6	285.1	494.7
4	5.3	185.8	180.5
5			
6	108.9	219.4	110.5
7	142.6	196.0	53.4
8	-433.0	-30.3	402.7
9	-26.7	-186.6	159.9
10	-291.0	122.8	413.8
11			
12	-281.8	124.3	406.1
13	14.8	213.3	198.5

n = 11
mean = 178.90
SEM = 68.70
p = 0.01

HC = after high carbohydrate-low fat diet at maintenance energy intake for 22 days

HF = after high fat-low carbohydrate diet at maintenance energy intake for 22 days

a = This is the free fatty acid concentration value at 360 minutes minus the fasting baseline free fatty acid concentration value. A negative value for HC or HF represents a value which was less than the fasting baseline free fatty acid value.

b = a liquid meal of same composition or the HC diet or the HF diet, respectviely, at 14.3 kcal/kg weight of fat-free mass

c = comparison of differences in the direction of HF minus HC

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Dissertation Committee:

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(signed in her absence)

Director of Graduate Program

Dean, UAB Graduate School

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