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THE RELATIONSHIP BETWEEN DIETARY INTAKE AND BODY COMPOSITION CHANGES OVER THE COURSE OF PREGNANCY

A Thesis

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Degree

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Hollie Anne Raynor

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ABSTRACT

The purpose of this study was to assess body composition and dietary intake changes during pregnancy and to examine the relationship between dietary intake and body composition during pregnancy. Twelve pregnant women (30.0 ± 6.5 years) participated in the observational, prospective study. Dietary intake was assessed by a semi-quantitative food frequency questionnaire, using two retention intervals: dietary intake during the year prior to pregnancy and dietary intake during the previous month. Height, weight, and bioelectrical impedance analysis were obtained using standard procedures and were utilized to establish body fat. Dietary intake and body composition measurements were taken once during each trimester (measurement one mean gestational age: 9.6 ± 3.3 weeks; measurement two mean gestational age: 20.3 ± 1.3 weeks; and measurement three mean gestational age: 31.8 ± 1.4 weeks), with 100% of the subjects completing the first two measurements and 58% of the subjects completing all three measurements. Results of the food frequencies indicated that while energy and macronutrient intakes increased over pregnancy, no statistically significant changes were found. Anthropometric measurements revealed that mean weight gain was 7.5 ± 5.4 kilograms and mean gain in body fat was 4.7 ± 3.3 kilograms. Changes in weight and body fat were statistically significant ($p \leq 0.05$) for each measurement, indicating an overall increase in weight and body fat during pregnancy. Correlation coefficients indicated there was a statistically significant association ($p \leq 0.05$) between changes in Food

Quotient (a measurement of macronutrient composition of the diet) and changes in weight, body fat, and body fat percent for the period between the first and second measurement. A statistically significant association ($p \leq 0.05$) was also found between changes in Food Quotient and changes in body fat percent between the second and third measurements. Multiple stepwise regression analysis found that the most consistent dietary variable that partially accounted for a significant amount of change in body fat over the course of pregnancy was change in Food Quotient. These results indicate that body fat deposition and weight gain over the couse of pregnancy may be influenced by dietary fat and carbohydrate intake, with a high-fat, low-carbohydrate diet associated with greater weight gain and fat deposition during pregnancy.

PREFACE

This thesis is divided into two parts. Each part is a separate unit with its own tables and list of references. The first part of this thesis is a literature review, covering the background for the development of this project. The second part of this thesis is written as a long journal article, covering the methodology, results, and discussion of the thesis project.

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PART I: INTRODUCTION, BACKGROUND, AND SIGNIFICANCE OF RESEARCH

PART II: THE RELATIONSHIP BETWEEN DIETARY INTAKE AND BODY COMPOSITION CHANGES OVER THE COURSE OF PREGNANCY

PART I

INTRODUCTION, BACKGROUND, AND SIGNIFICANCE OF RESEARCH

INTRODUCTION

More than 34 million adults are considered to be obese in the United States (1). Research has shown that individuals with excessive body weight and/or body fat are at increased risk for elevated morbidity and mortality from several diseases, including coronary artery disease and non-insulin dependent diabetes mellitus (1). The incidence and prevalence of obesity are increasing (2), and the causes of obesity still elude medical science (3).

Shah et al. (4) found that from 1980 to 1987, females' body mass index (BMI) and the prevalence of obesity in females had significantly increased. This study proposed that the female population is getting "fatter" and the incidence of severe obesity in females is accelerating (4). If this is true, the increased risk of chronic disease development in females due to increased incidence of obesity will greatly impact the health care system and could drive up health care costs.

Sheldon (5), in 1949, was the first to propose the theory of increased adiposity development in association with pregnancy. Postpartum residual weight may be due to factors indirectly associated with pregnancy, such as lifestyle changes associated with caring for children (6), or to factors directly related to pregnancy, such as excessive caloric intake or macronutrient composition of the diet during pregnancy (7). Since many studies have found an association between high dietary fat intakes and increased adiposity levels, high dietary fat intakes during pregnancy may increase the amount of weight gain and fat deposition that occurs during pregnancy.

Several investigations have reported a relationship between parity and obesity (8,9). Tonkelaar et al. (8) found that the BMI and waist-to-hip (W/H) ratios enlarge with increasing parity. BMI and W/H ratios correlate to body fat, and increases in these ratios are associated with the development of chronic disease, which impact the quality of life. Forster et al. (9) also found a strong positive association between the number of births and BMI. The results of the study by Forster et al. (9) indicated that residual weight gain in pregnancy may be explained, in part, by the number of births.

To further define obesity development associated with pregnancy, body composition changes that occur during pregnancy need to be delineated into fat mass and fat-free mass. There are many methods to measure body composition. However, most methods for body composition measurement are inconvenient, costly, and not suitable for use in a patient setting (10-12). One method for estimating body composition that is portable and relatively inexpensive, rapid and accurate, and provides reliable and sufficient measures of body composition in a field setting is bioelectrical impedance analysis (BIA) (13). Many equations for fat-free mass, percentage body fat, and total body water have been validated for use in certain populations (13,14), including pregnant females (15).

To assess the relationship between dietary factors and body composition changes during pregnancy, dietary intake must be estimated. The food frequency method has been used to assess the diets of different populations. Research has found this method to be valid and reliable when used to assess dietary intake during pregnancy (16,17).

If the relationship between dietary fat and body composition during pregnancy were more clearly understood, policies regarding diet composition during pregnancy could be developed and nutritional strategies could be implemented. This knowledge would allow physiological needs to be met during pregnancy without providing excess nutrients, thus decreasing the development of obesity postpartumly, thereby decreasing or delaying the onset of chronic disease in females.

Specific Aims

The purpose of this investigation was to assess the relationship between dietary fat intake and body composition alterations prospectively during pregnancy, as reported by a self-administered, semi-quantitative food frequency questionnaire and as measured by bioelectrical impedance analysis (BIA). Accordingly, this project addressed two broad objectives:

1. Assess body composition and dietary intake in a group of healthy females during pregnancy (one measure per trimester); and
2. Analyze body composition and dietary intake data to determine the inter- and/or intra-individual relationships between these two variables over the course of pregnancy.

Thus, the following hypothesis was investigated in the project: there will be a positive association between energy intake as fat, either independently or corrected for energy intake, and fat deposition during pregnancy.

BACKGROUND AND SIGNIFICANCE

Health Problems Associated With Obesity

Obesity is very prevalent in the United States, affecting more than 34 million adults (1). It has long been recognized that overweight individuals have substantially higher death rates than individuals of normal weight (18). Research has unquestionably shown that individuals who have excessive body weight and/or body fat are at increased risk for several health problems, including elevated morbidity and mortality from coronary artery disease (CAD), certain cancers, non-insulin dependent diabetes mellitus, hypertension, hypercholesterolemia, and abnormal pulmonary function, among other diseases (1,2,19,20).

As well as posing as a potential health hazard, obesity also can be a physical handicap (18). As fat-bearing tissue increases, its constant mechanical support and maintenance becomes an increasing effort (18). Research also has shown that obesity carries a social stigma, therefore precipitating negative social attitudes towards obese individuals (2).

Despite serious efforts to prevent obesity, the incidence and prevalence of obesity are increasing (2), and the causes of obesity still elude medical science (3). The three factors which are usually accepted as controlling fat deposition in the development of obesity are heredity, diet, and energy expenditure (21). For the formulation of nutritional strategies to prevent and/or treat obesity, a better understanding of the factors that influence the pathophysiology of energy balance is required (2). One factor needing further investigation in regards to energy balance is the development of obesity due to increased fat gain during pregnancy.

Obesity Associated With Parity

The theory of increased adiposity development in association with pregnancy was examined first by Sheldon in 1949 (5). For postpartum females, failure to return to pre-pregnancy weight is of great concern, particularly if there is excessive weight gain during pregnancy (22). Due to reported postpartum weight retention, Lederman (23) states that maternal obesity particularly needs to be examined in studies of nutrition during pregnancy. Postpartum residual weight may be due to factors directly associated with pregnancy, such as excessive caloric intake or macronutrient composition of the diet during pregnancy (7), or to factors indirectly related to pregnancy, such as changes in lifestyle associated with caring for children (6).

In 1990, the Institute of Medicine published its report, *Nutrition During Pregnancy* (24), which stated the optimal weight gain during a normal pregnancy is 25-35 pounds. However, generating standards for optimal maternal weight gain during pregnancy has been hindered by the acknowledgment that the relative components of weight gain during pregnancy are unclear (25). One of the poorly defined components that contributes to most of the weight gain during pregnancy apart from the products of conception is maternal fat (25,26). Women from developed countries gain an estimated 2-4 kilograms (4.4-8.8 pounds) of body fat during pregnancy, and it has been appraised that most of the fat deposition occurs during the second trimester (27). It has been suggested that more research is needed to determine if there is a relationship between body fat deposition and amount of weight gained during pregnancy in individual women (24).

Current studies have focused more on body composition changes associated with pregnancy that increase body mass index (BMI) and waist-to-hip (W/H) ratios (6-9,28,29), which in turn correlate to body fat. These increases are associated with the development of chronic disease, which reduce the quality of life.

Shah et al. (4) examined secular trends in BMI and obesity over a seven-year period. When adjusted for age and education, it was found that females had an increased BMI of 0.19 kg/m^2/year in contrast to the increase in BMI of 0.08/kg/m^2/year for males. Also, prevalence of obesity (specified as $\geq$ 85th percentile at Year 1) increased in females by 1.0 percent per year. The authors of this study proposed that the female population as a whole is getting "fatter" and the prevalence of severe obesity is accelerating. It was suggested that the increase in obesity in females may be due to factors exclusively related to having children or combined with dietary factors and the exercise habits of most Americans.

The first study in the United States that looked at the relationship between obesity and parity examined BMI and reproductive histories of black and caucasian women (9). In caucasian women, a strong association was found between the number of births and BMI, independent of age, suggesting that the residual weight gain in pregnancy may be explained, in part, by number of births.

Tonkelaar et al. (8) investigated a large sample of women aged forty and older from The Netherlands to assess W/H ratios. It was determined that increased fat distribution was positively associated with parity and current smoking status in pre- and postmenopausal women. The BMI and W/H ratio also increased with increasing number of children.

Many factors influence the development of obesity. One factor that could influence weight gain during pregnancy, and in turn could influence the development of obesity postpartumly, is the macronutrient composition of the diet, particularly dietary fat, consumed during pregnancy. Williamson and Lund (26) reported that lipoprotein lipase activity in adipose tissue has been found to increase in rats during pregnancy. Lipoprotein lipase is the initiating enzyme for triacylglycerol metabolism in adipose tissue, causing free fatty acids to be released from chylomicrons (packages of dietary triglycerides). These free fatty acids can be stored in the adipose tissue, thereby increasing adiposity. If this is true in humans, this could be a mechanism for how dietary fat could influence body fat changes during pregnancy. By identifying the relationship between dietary fat and body composition changes during pregnancy, nutritional strategies could be developed to decrease the development of obesity postpartumly, thereby decreasing or delaying the onset of chronic disease.

Body Composition Assessment in Pregnancy

During the 1940's, research began to establish indirect methods of body composition measurement (30). Subsequently, a variety of methods have been introduced. Lukaski (30) describes traditional methods, which are based on established approaches to body composition, and nontraditional methods, which reflect contemporary hypotheses and technology, currently used to estimate body composition. See Table 1 for a review of traditional and nontraditional methods of body composition measurement. Most body composition methods are based upon the two-compartment model of fat and fat-free mass (31). It is assumed the fat-free mass is relatively constant (30).

There are problems estimating body composition during pregnancy. In pregnancy, changes in body water occur and consequently the usual assumptions for fat-free mass are no longer valid (10,11). During pregnancy, extracellular fluid is retained, thereby increasing the hydration of the fat-free mass (12). This increase in hydration during pregnancy can lead to overestimation of total body water and fat-free mass and underestimation of total body fat, if the standard formulas are used to estimate body composition (10-12). Therefore, equations specific for pregnancy need to be used when body composition is being measured during pregnancy.

van Raaij et al. (11) developed new densitometry equations for pregnancy

Table 1. Limitations of Body Composition Measurement Methods[a]

Method	Cost	Technical Difficulty	Precision: Fat-free Mass	Precision: % Fat
Traditional				
Water	2	3	3	3
Deuterium	5	5	4	4
Tritium	3	3	3	3
Potassium	4	4	4	3
Creatinine	2	3	2	1
Densitometry				
Immersion	3	4	5	5
Plethysmography	4	3	5	5
Skinfold thickness	1	2	2	2
Arm circumference	1	3	2	2
Non-traditional				
Neutron activation	5	5	5	5
Photon absorptiometry	4	4	4	4
3-Methylhistidine	2	3	3	?[b]
Eletrical				
Conductivity	5	1	4	4
Impedance	2	1	4	4
Computed tomography	5	5	?[b]	?[b]
Ultrasound	3	3	3	3
Infrared interactance	4	3	3	3
Magnetic resonance	5	5	?[b]	?[b]

Source: Lukaski HC. Methods for the assessment of human body composition: traditional and new. *Am J Clin Nutr*. 1987;46:537-556.

[a]Ranking system: ascending scale, 1 = least and 5 = greatest.

[b]Unknown at this time.

in a Dutch study of 42 healthy pregnant women, based upon densitometric measurements taken at 6-week intervals. It was suggested that these new equations should be used to estimate body composition during pregnancy; the equations resulted in more valid estimates of maternal fat mass.

A later study by van Raaij et al. (32) using this new equation to estimate body composition during pregnancy found that there was an approximate total gain of 2 kilograms in fat stores during pregnancy for 57 Dutch women. It was also determined that the changes in fat stores during pregnancy could be estimated to be +0.5 kilograms for the first trimester, +2.0 kilograms for the second trimester, and -0.3 kilograms for the third trimester. However, the authors did state that the variation in weight gain in fat stores over pregnancy was quite substantial. Approximately 60% of the subjects had a gain in fat stores of 0-4 kilograms, while 20% showed a decline in fat stores and another 20% showed a gain of > 4 kilograms in fat stores.

Villar et al. (33) also examined the components of weight gain during pregnancy. Body fat and fat-free mass were calculated with anthropometric and bioimpedance measurements. The equations to determine body fat and fat-free mass were developed specifically for the study and were based on body composition measurements obtained through densitometry. The results showed that body fat represented the largest component of tissue gain during pregnancy. The mean total maternal weight gain was 375.1 grams/week, with 231.3 grams/week of fat and 192.5 grams/week of fat-free mass. It was discovered that the period of largest fat deposition was between the twentieth and thirtieth week and the greatest gain in fat-free mass was between the twentieth week continuing until term.

As stated earlier, there are several methods to measure body composition. However, only a few of these methods are applicable for field use or for use with patients; most methods are inconvenient, expensive, and require active cooperation of the patient (13,34,35). Other techniques developed for use in the field, such as anthropometry, skinfold thickness measurements, and infrared interactance, are less reliable predictors of body composition (13). Consequently, there is a need for a safe, relatively inexpensive, non-invasive technique, that is rapid and accurate and provides reliable and sufficient measures of body composition in a field setting (13). Measurement of bioelectrical impedance to determine body composition may meet this need (13).

Bioelectrical Impedance

The method of determining body impedance is based upon the conduction of an applied electrical current in the organism (36). Application of constant low-level, alternating currents causes an impedance to the spread of the current that is frequency dependent in biological structures (30,36). Bioelectrical impedance analysis (BIA) measures the body impedance with low-level (usually 800 *u*A at 50 KHz) currents transported through the tissues (37). Body fluids and electrolytes, which are contained primarily in lean tissues, represent highly conductive, low-resistance electrical pathways (38). Since the fat-free mass contains electrolytes, it functions like an electrical conductor with electrical properties highly dependent on the ionic states, therefore conductivity is greater in the fat-free mass (30,36,37,39). Skin, fat, and bone are high-resistant electrical pathways, which contain low amounts of fluids and electrolytes (38). Body fat, total body water, and extracellular fluid are resistant to electrical current (38).

BIA relies on the three-compartment model of body composition, rather than the usual two-compartment model of body composition on which many methods of body composition estimation are based (38). The three-compartment model delineates body fat, and intracellular and extracellular mass (fat-free mass) as the three compartments in the body (38). The three compartments are not of a fixed size, therefore allowing weight changes to occur in fat, intracellular mass, and extracellular mass (38).

According to Kushner (40), "impedance (Z) is a function of resistance (R) and capacitance (Xc) of the conducting substance, such that:"

$$Z^2 = R^2 + Xc^2 \text{ (41)}$$

R is equal to the opposition to the flow of an alternating current, whereas Xc is the opposition to the flow of electrical current caused by capacitance (reactance) produced by tissue interfaces and cell membranes (40). It is assumed whole-body R predominately measures total body water (TBW), while Xc may provide an estimate of the extra-cellular water/intra-cellular water ratio (40). The results of two studies (42,43) support the hypothesis that Xc is a plausible impedance variable that can be used to estimate extracellular water and intracellular water compartments.

In the United States, the pioneering work of bioelectrical impedance was performed by Jan Nyboer in 1939-1940 (41). However, it was Thomasset (44) who conducted the original studies using electrical impedance measurements as an index of total body water. Hoffer et al. (45) were the first to use bioelectrical impedance to determine total body water in humans.

Bioelectrical impedance variables have been measured using either the bipolar or tetrapolar approaches (46). The bipolar method used steel needle electrodes placed subdermally. This method was found to induce volunteer discomfort and electrochemical reactions that interfered with impedance measurement (46). Due to the disadvantages of the bipolar method the tetrapolar method was developed (46). The tetrapolar method uses four surface electrodes and minimizes volunteer discomfort and contact impedance or skin-electrode interactions (46).

The resistance of a non-biological conductor to an electrical current is directly proportional to the length of the conductor and inversely proportional to its cross sectional area, according to Ohm's law (47). Therefore, with BIA, theoretically, the fat-free mass is directly related to body height^2/body resistance (H^2/R) (39,47), and indirectly to total body fat or percent body fat (48), when body resistance or bioimpedance is measured with a tetrapolar electrode configuration (48). In determining percentage body fat with bioelectrical impedance, Van Loan (14) reported that the additional use of anthropometric measurements (weight or skinfold thickness measurements) in the equation improves the predictions of percentage fat over just the use of bioelectrical impedance measurements. However, the multiple R associated with the estimation of percentage of body fat (R^2 = 0.76 to 0.93 for percent body fat) has tended to be lower than that of the multiple R associated with the estimate of fat-free mass (R^2 = 0.80 to 0.98 for fat-free mass) (14). Additionally, Segal et al. (48) stated that the BIA method appears to measure lean mass quantitatively, or more specifically, hydrated lean tissue, more so than body fat or percent body fat.

Certain factors must be taken into consideration with the use of BIA. Fasting state, phase of the menstrual cycle, physical activities performed immediately before the measurements, and hydration status all seriously influence the impedance measurements (39,49). Also, obesity influences the accuracy of measurements; research has shown a systemic overestimation of fat-free mass with increasing obesity (50-52). Deurenberg et al. (53) also examined the effects of age and gender on body composition estimation from BIA and they found that for older adults and females, there is a lower intercept of the regression equation than that for younger adults and males.

One problem with the validation and development of bioelectrical impedance equations is that the "reference" methods (densitometry, hydrometry, etc.) are not error free themselves (14). The error associated with the densitometric method in estimating percent body fat is estimated to be 2.5% (38,50). Therefore, this 2.5% error represents the maximum precision possible in estimating body composition with other methods when densitometry is used as the reference point (38). The estimated error associated with bioelectrical impedance in estimating body fat has been reported to be 2.7% (30) and 5-6% (35). The estimated error associated with anthropometry is 3.9 to 9% (50), and furthermore, some studies have stated that BIA does no better at estimating percentage body fat than skinfold thickness measurements (49,54,55).

For estimating body composition, BIA has many advantages. This method is portable, independent of inter-observer errors, easy to perform and a non-invasive technique that requires only a few minutes, and subjects do not need to undress for the measurement (49,53,54). There also appears to be consensus in the literature that BIA has promise in the estimation of body composition, and many equations for fat-free mass, percentage body fat, and total body water have been validated for use in certain populations (13,14), including pregnant females (15). These qualities enhance BIA's usefulness in estimating body composition in field studies and in practice. Finally, to reduce possible error, it is recommended that bioelectrical impedance prediction equations should be population specific and bioelectrical impedance measurements should be obtained by the same type of instrument that was used in the development of the population specific equations (15).

Dietary Fat Implications

Many studies have assessed the influence of dietary fat on body weight and composition. A review article by Rolls and Shide (56) stated that high fat foods promote obesity. It was noted also that as body fat increased, there was an increase in percentage of calories derived from fat.

The weight changes of 303 women over one and two years were examined by Sheppard et al. (57). The subjects were participating in a low-fat dietary intervention trial. It was found that weight loss was more strongly associated with percent calories from fat than from the change in total caloric intake, suggesting that body fat is a function of energy balance and percent of energy from fat.

Klesges et al. (58) longitudinally analyzed the relationship between dietary intake, physical activity, and body weight change in 142 men and 152 women. They found that dietary fat was the only variable that consistently predicted body mass and weight gain in men and women.

The effects of a diet with 20% calories from fat on total body weight, lean body weight, and adiposity were studied in 18 women by Prewitt et al. (59) after the subjects were fed a control diet (37% calories from fat) for four weeks. Despite adjustments in energy intake to maintain weight throughout the study, the subjects showed a 2.8% decrease in total body weight ($p < 0.0006$), an 11.3% decrease in body fat weight ($p < 0.0001$), and a 2.2% increase in lean body weight ($p < 0.0149$) by the end of the twenty weeks on the low-fat diet. The authors stated that the results could not be explained by changes in activity levels and hypothesized that macronutrient composition in the diet plays an important role in weight maintenance.

A study by Kasim et al. (20) studied 72 healthy females receiving either 15% calories from fat or their usual diet (approximately 36% calories from fat). It was found that the reduction in dietary fat was associated with decreased energy intake and body weight. Interestingly, the correlation between average weight loss was higher for the percent of energy obtained from fat than for total energy intake. This again suggests the restriction of fat intake may be more effective than restriction of total caloric intake for weight loss.

An intervention study performed by Bjorkelund et al. (28) in Sweden discovered that abdominally obese women (BMI $\geq$ 30 and/or W/H ratio $\geq$ 0.82) were able to make significant changes in their body compositions by attending dietary classes and participating in an exercise program. As compared to a group of corresponding non-participants, the subjects significantly reduced their body weight, BMI, waist circumference, and W/H ratio. The subjects' triglyceride levels also decreased by 21% as compared to the controls.

The relationship among body fat, dietary composition, energy intake, and exercise in 109 females was examined by Miller et al. (60). A 0.81 correlation was found between body fat and body weight, and a 0.37 correlation ($p < 0.001$) between body fat and dietary fat was also found. It was concluded that as the percentage of energy from fat increased, body fat also increased, although body fat had an inverse relationship with percentage of energy from carbohydrate. It was also discovered that there was no relationship between energy intake and adiposity. This data suggests that body fat is related to exercise and dietary composition rather than to energy intake, thereby suggesting that dietary composition plays a role in fat deposition.

Dreon et al. (61) compared 7-day diet records to hydrostatically determined body composition in 155 obese men. Percent body fat was positively correlated ($p < 0.05$) with g/1000 kcal intake of total, saturated, and monounsaturated fatty acids and negatively correlated ($p < 0.05$) with g/1000 kcal intake of carbohydrates and plant protein. The authors stated that the lack of correlation between body fat and total energy intake suggests that energy differences are not the major cause of the variations in obesity in the subjects studied.

A study by Tremblay et al. (62) measured food intake (3-day dietary records) and skinfold thickness in 244 healthy males. Significant positive correlations were found between the percentage of energy from fat and body fat mass ($p < 0.01$), percent body fat ($p < 0.05$), sum of trunk skinfold thicknesses ($p < 0.01$), and sum of extremity skinfold thicknesses ($p < 0.05$). Correlations between the percentage of energy from carbohydrate and fatness indicators were in the opposite direction, but were also significantly different.

The relationships between dietary fat intake, adiposity, and regional subcutaneous fat distribution were examined in 344 men and 335 women by George et al. (63). It was discovered that men and women with a higher percentage of energy from fat weighed significantly more ($p < 0.05$), and had higher total subcutaneous fat distributions ($p < 0.01$) than subjects with a low-fat intake. These results suggest that when high-fat consumers are compared to low-fat consumers, a greater percentage of calories from fat intake influences total adiposity, as well as regional subcutaneous fat distribution.

The relationship of dietary fat with body fat was examined by Tucker and

Kano (3) in 205 females. In this study, the National Cancer Institute's *Health Habits and History Questionnaire* was used to assess dietary intake and skinfold-thickness measurements were used to assess body fat. Even when multiple confounding variables (age, total energy intake, total exercise time per week, years of regular physical activity, consumption of other micronutrients, and smoking) were controlled, dietary fat was related significantly with adiposity ($F = 8.74$, $R^2 = 0.033$, $p = 0.0035$). However, the authors did recommend that more research in the area of fat intake and adiposity in humans is needed, especially in states of positive energy balance.

A relatively new concept in studies regarding the influence of dietary fat intake on weight and body composition is the Food-Quotient (FQ). Flatt (64) stated that body composition and weight remain unchanged only if metabolic responses cause biological oxidation of a metabolic fuel mix that is equivalent to the dietary macronutrient mixture, in amount and composition. Flatt compares the FQ, the ratio of carbon dioxide produced to the oxygen consumed during oxidation of the macronutrient mixture consumed, to the Respiratory Quotient (RQ), which is the ratio of carbon dioxide produced to oxygen consumed during actual metabolism (64). When RQ is equal to 1.0, primarily carbohydrates are oxidized (metabolized), but as RQ declines to 0.7, fat becomes the primary fuel that is oxidized by the body. The FQ ranges from 0.7 to around 1.0 (about the same ranges as the RQ), with high-fat diets resulting in a FQ of around 0.7 and high-carbohydrate diets resulting in a FQ of around 1.0. According to Flatt, it is postulated that if the RQ is higher than the FQ, the body will strive to maintain glycogen reserves by storing dietary fat via inhibition of beta-oxidation, causing a slight enhancement in hunger, thereby increasing dietary intake. Flatt theorizes that an individual with a FQ lower than RQ will store fat due to inhibition of fat oxidation, unless caloric intake is relatively low to metabolic needs. However, if the RQ is lower than the FQ, then fat oxidation will occur, thereby causing the body to utilize fat stores, perhaps even if caloric intake matches energy expenditure.

The formula for FQ is (62,65):

FQ = (kilocalories as protein/total kilocalories X RQ protein) + (kilocalories as lipid/total kilocalories x RQ lipid) + (kilocalories as carbohydrate/total kilocalories x RQ carbohydrate);
with RQ protein = 0.8; RQ lipid = 0.7; and RQ carbohydrate = 1.0.

As indicated in the formula, the FQ provides an overall indicator of macronutrient composition of the diet. The FQ has been used as a standard in studies that have looked at the relationship between dietary fat intake and body composition, because it not only provides an indication of dietary macronutrient composition, but also takes into consideration caloric intake (62,65). RQ does not have to be measured to interpret FQ (62,65).

In a state of positive energy balance such as pregnancy, conceivably individuals with lower FQs are more at risk for fat deposition. However, the adjustments of macronutrient metabolism in pregnancy (increase use of fatty acids as a fuel source to conserve glucose as a fuel source to the fetus) (66) may prevent Flatt's FQ theory to be of use in explaining body composition changes that occur during pregnancy.

The first researchers to separate the influence of dietary intake on body composition from the normal physiological adjustments in pregnancy were Emerson et al. (7). Three healthy women and two women with diabetes were hospitalized for one week, each month, during their pregnancies. During the hospitalizations, the women were given measured diets of constant composition which approached their usual food intake as closely as possible, except in all instances the daily protein intake exceeded 75 grams. The results of this study showed that body fat storage in normal pregnancy is regulated by the energy content of the diet, just as it is in the nonpregnant female. As caloric intake is restricted, fat accumulation decreases, and vice-versa.

If dietary fat is found to be the main contributor to adiposity development and "excess dietary fat" could be specified, then perhaps the diet composition could be refined so that physiological needs in pregnancy (a positive energy balance state) could be met without providing "excess dietary fat." Then possibly, the fat accumulation that occurs during pregnancy might be diminished. This, in turn, could lead to less residual fat from pregnancy, thereby decreasing the prevalence of the development of obesity for child-bearing females, consequently decreasing the risks for developing chronic diseases.

Dietary Fat Trends in the United States

One of the most significant changes in food habits that has occurred since the beginning of the century in industrialized countries is the increase in the contribution of fat to energy intake (67). In 1976, fat provided 31% more of our calories than in 1910, despite an overall reduction in energy intake (68).

Thompson et al. (69) reported that according to data gathered by the 1985-1986 Continuing Survey of Food Intakes by Individuals (CSFII) that included 2,134 females aged 19 to 50, females are consuming more than the recommended intakes for fat. Although the portion of energy derived from fat had decreased from 40.8% in 1977-78 to 36.8% in 1985 (69), 36.8% of energy obtained from fat does not meet the Dietary Guidelines for Americans of less than 30% calories from fat.

According to data from the Third National Health and Nutrition Examination Survey (NHANES III), Phase 1 (October 1988 to October 1991), the percentage of daily total food-energy intake from dietary fat for individuals in the U.S. over the age of 2 years is 33.9% (70). For females greater than two years of age the percentage of daily total food-energy intake from dietary fat is 33.8% (70). This survey included 14,801 individuals with complete dietary information. While again, these results show a decrease in the amount of energy obtained from fat, the Dietary Guidelines for Americans for dietary fat intake are still not met.

The same trends of high-fat consumption were found by Georgiou and

Arquitt (71) in a study of 199 undergraduate females enrolled in introductory nutrition courses. The main contributors to fat intake in the subjects were the higher fat desserts, cheeses, and grain mixtures.

Kushi (72) reports that because the U.S. average dietary fat intake is so high, studies conducted in the U.S. that look at the implications of dietary fat intake have a unique problem. According to Kushi (72), the problem with observational studies is recruiting subjects into a study who adequately represent lower dietary fat intakes. Only with adequate representation of subjects in a study with low- and high-intakes of dietary fat can investigators ascertain the influence of dietary fat on the dependent variable of interest.

There are many methods, based upon recall or report, that can provide dietary data. To compare fat intake versus fat deposition in the body, the composition of the diet, specifically in regards to fat intake, must be determined first. After dietary intake data have been collected, the amounts and types of food consumed can be analyzed to identify the composition of the macronutrients in the diet.

Assessing Dietary Composition

As stated earlier, there are several methods that have been developed and used to collect and assess the dietary intake of individuals. A self-administered, semi-quantitative diet history questionnaire based upon dietary data from 11,658 people in the Second National Health and Nutrition

Examination Survey (NHANES II from 1976-1980) was developed by Block et al. (73). This questionnaire is now the National Cancer Institute's *Health Habits and History Questionnaire* (NCI Block). With one-day food records, the questionnaire was validated, with an overall correlation of 0.70 and a 0.74 correlation with dietary fat. The food list in the questionnaire contains 94.7% of the foods which represent the total dietary fat intake in respondents of the NHANES II. Foods included in the questionnaire make an important contribution to the population's energy intake and contain each of the 17 nutrients in the NHANES II database.

The questionnaire listed portion sizes as small, medium, and large. The subjects were allowed to choose portion size and eating frequency of the foods on the list. However, limiting the choice to standard medium portion size provides accurate estimates in females (73).

Block et al. (74) modified the questionnaire in a validation study using 277 four-day diet record means from females aged 45 to 70. The four-day diet records were collected over the year prior to administration of the diet history questionnaire. Block et al. (74) found the control group had the same percentage of calories from fat (37.7%), measured by both the four-day food records and the diet history questionnaire. The food records revealed the low-fat group (intervention group) consumed 21.3% calories from fat, while the questionnaire showed this group consumed 23.7% calories from fat. Correlations between the diet records and the diet history questionnaire for percent calories from fat were 0.67 for the control group and 0.65 for the intervention group. The majority of the correlations for other nutrients were in the 0.5-0.6 range.

In 1992, Block et al. (75) performed another validation study comparing two diet history questionnaires, the NCI Block and the University of Michigan questionnaires. Reference data for the validation of the questionnaires were four-day food record means, collected the previous year. The subjects in the study were 85 black and white females and males, aged 25 to 50. The study discovered that the University of Michigan questionnaire consistently overestimated nutrients when compared to the food records. The NCI Block questionnaire provided correlations of 0.56 with protein, 0.58 with fat, 0.62 with energy, and 0.68 with carbohydrates.

Krall and Dwyer (76) evaluated the validity of the NCI Block food frequency questionnaire with a food diary in a short-term recall situation. For 14 days, 19 participants were monitored in a metabolic research facility. The food provided to the subjects was from a three-day cycle menu and was weighed before it was presented to the participants. For the two weeks participants were monitored, the participants completed a three-day food record and one food frequency questionnaire per week. Results of the study indicated that all nutrients were significantly underestimated by the food frequency questionnaire.

Willett et al. (77) also validated a self-administered, semi-quantitative food frequency questionnaire. In this study, a comparison between the results of the questionnaire with a one-year diet record of 27 subjects taken 18 months prior to administration of the questionnaire was performed. It was discovered that the estimates of the mean nutrient intakes from the questionnaire were within 10% of the mean diet record measurements for 11 of 18 nutrients evaluated. For total fat, the correlation coefficient was 0.76, and those for saturated fat, polyunsaturated fat, and cholesterol were all greater than 0.65. The overall mean coefficient was 0.60 for the 18 nutrients measured. These results propose that this food frequency questionnaire can provide information on dietary intake over an extended period of time.

A "modified" version of an established food frequency questionnaire has been used by several studies (74,75,77). The modified questionnaire uses a standardized portion size (medium), rather than allowing respondents to choose from small, medium, or large portion sizes. A study by Hunter et al. (78) examined whether the modified questionnaires with the standardized portion size introduced any errors. The results suggested that the use of the standard portion size (medium) may not introduce large errors in establishing the food and nutrient intakes of females.

While food frequencies are a helpful tool in assessing dietary data, food frequencies have their faults. Sempos (79) commented that while the correlations of greater than 0.60 might appear to be good, a few random 24-hour dietary recalls or multiple food records may provide better estimates of absolute intake in an individual. However, Hunter et al. (80) stated that the traditional practice of using dietary records or recalls as the "gold standard" in the assessment of the validity of food frequency questionnaires may "substantially underestimate the validity of food frequency questionnaires." Dietary records and recalls are not without their own faults. The process of keeping dietary records may alter an individual's diet, thereby misrepresenting normal dietary intake (80), while dietary recalls represent one day of intake and the results may not represent usual dietary intake (81).

Quantitative food frequencies were discovered to underestimate the mean percent calories from fat and protein and to overestimate the mean percent calories from carbohydrates when compared to 16-day food records in an investigation by Flegal and Larkin (82). However, the correlations in percentages of calories derived from the macronutrients were higher than the correlations for absolute amount of macronutrients. Consequently, the authors recommended that percent of macronutrients be used rather than absolute amounts of macronutrients in dietary assessment.

In 1992, Briefel et al. (83) described the limitations of the NCI food frequency. First, the authors reported that Block et al. (74) used dietary data from 1976-1980 to construct the food list and portion sizes for the food frequency questionnaire. Second, due to the use of broad categories of foods, the portions of the foods are not well defined. Lastly, the food frequency is not culturally sensitive, and thus is of limited use. The authors suggested the NCI food frequency should be used in a homogenous population rather than used in collecting national survey data.

Finally, it has been noted by Zulkifli and Yu (84) that the food frequency method of dietary assessment was designed originally to describe dietary patterns and habits rather than absolute nutrient intakes. The authors stated that for best validity and reliability, the food frequency should be used for ranking or monitoring patterns over time only. However, macronutrients were found to be more highly correlated to energy than other nutrients, suggesting that food frequencies are better at determining macronutrients in the diet than other nutrients.

The food frequency method of dietary assessment is not without problems. However, when used to assess a homogenous population's diet, it appears that validity and reliability can be established, enabling the comparisons of dietary intakes at the group level.

Dietary Assessment in Pregnancy

The problem of reliability of quantitative historical estimation of nutrient intake during pregnancy was studied by Rush and Kristal (85) in 520 low-income black women. The authors determined that repeated 24-hour recalls are reliable measures of nutrient intake in pregnancy for large scale studies.

Endres et al. (86) studied dietary intakes of 63 low-income, pregnant females, 35 years and older, and 526 pregnant adolescents via a 24-hour recall. It was discovered that both groups consumed less than the recommended dietary allowances for energy. It was also found that the older women were more likely to be obese prior to pregnancy.

In a study by Suitor et al. (16), food frequency and dietary recall methods were used to assess nutrient intake of low-income, pregnant females. A newly developed self-administered, semi-quantitative food frequency questionnaire was used to assess the intakes of the population studied. Portion sizes were assigned to each food item, based upon median portion size in grams reported for women aged 19 to 29 in the NHANES II. The conclusion of this study was that the new questionnaire did provide beneficial data about recent intakes of selected nutrients, but 20% of the sample overestimated food intake. The authors suggested that a food frequency questionnaire targeted toward the pregnant population could collect data on recent dietary intake and changing appetite and food patterns.

A group of 335 low-income, culturally-diverse, pregnant women in Massachusetts was investigated by Suitor et al. (17). The Prenatal Food Frequency Questionnaire was used to calculate an Index for Nutritional Quality in the subjects' diets. Energy, protein, and the micronutrients were the nutrients of focus in this study.

All of the studies previously mentioned in this section used low-income females as subjects. The studies measured micronutrients, protein, and energy intake to identify who was not reaching the Recommended Dietary Allowances for the nutrients studied. Dietary fat was not measured, and the studies did not address the implications of overconsumption during pregnancy, suggesting a need to assess the effects of dietary fat and overconsumption in pregnant women.

Some studies have shown that pregnant women are willing to alter their diet during pregnancy (87,88). During pregnancy there appears to be more motivation to decrease the consumption of alcohol and caffeine, and to quit or reduce the amount of smoking during pregnancy (87,88). Perhaps pregnant women may be more willing to alter their diet in terms of fat content if dietary fat is found to be positively associated with body fat during pregnancy.

Summary of Literature

It has been established that obesity is associated with increased morbidity and mortality. Research has found that pregnancy affects body composition and perhaps the development of obesity postpartumly. A promising method to estimate body composition in pregnant females in a field setting is bioelectrical impedance analysis. Dietary fat has been found to play a part in the development of obesity in nonpregnant individuals. Consequently, if the relationship between dietary fat and body composition in pregnancy were better understood, the parts they play in the development of maternal obesity might also be better understood. With this understanding, weight gain recommendations for pregnancy could be expanded to specify the amount and type of weight gain desired based upon pre-pregnancy body composition (23). Finally, the association of dietary fat to body composition would allow for more individualized dietary recommendations made during pregnancy, thereby better meeting the needs of the pregnant population.

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PART II

THE RELATIONSHIP BETWEEN DIETARY INTAKE AND BODY COMPOSITION CHANGES OVER THE COURSE OF PREGNANCY

INTRODUCTION

More than 34 million adults are considered to be obese in the United States (1). Excessive body weight and/or body fat are associated with increased risk for elevated morbidity and mortality from several diseases, including coronary artery disease and non-insulin dependent diabetes mellitus (1). The incidence and prevalence of obesity is increasing (2), and the causes of obesity still elude medical science (3).

Obesity development in association with pregnancy has been noted in the literature since 1949 (4). Postpartum residual weight may be due to factors either directly related to the pregnancy itself, such as excessive caloric intake or macronutrient composition of the diet during pregnancy, or as a result of the changes in lifestyle associated with having children (5).

Postpartum residual weight can increase the waist-to-hip (W/H) ratio and body mass index (BMI) in women. Shah et al. (6) reported an increase in the prevalence of obesity during the 1980's, as well as a significant increase in women's BMI. Several investigators have reported a relationship between parity and obesity (7-10). Tonkelaar et al. (7) found that with increasing parity there was an increase in W/H ratio. Increased W/H ratios have been shown to be associated with chronic diseases, such as cardiovascular disease, stroke, and diabetes (7,8). Forster et al. (9) discovered a positive association between the number of births and BMI among caucasian women, independent of sociodemographic characteristics, suggesting that number of births may account, in part, for postpartum weight gain.

To further define obesity development associated with pregnancy, body composition changes that occur during pregnancy must be delineated into fat-free mass and fat mass to clarify how much adiposity development during pregnancy is too much. Unfortunately, there are few methods to measure the body composition of pregnant women. Hydrostatic weighing is accurate, but not practical in a prenatal clinic (11). While anthropometric measures are practical in a clinic, they are considered to be less reliable in predicting body composition (12). Bioelectrical impedance analysis (BIA) is portable and relatively inexpensive, rapid and accurate, and provides reliable and sufficient measures of body composition in a clinic setting (12). A BIA equation that determines fat mass and is specific for pregnancy has been previously developed (13), thereby allowing body composition changes in pregnancy to be measured in a clinic setting.

Excessive energy intake, as well as the macronutrient composition of the diet, may influence the development of obesity during pregnancy. In non-pregnant individuals, a positive association between high dietary fat intakes and increased adiposity levels has been reported (14-18). If the association between high dietary fat intakes and increased adiposity levels also occurs in pregnancy, high dietary fat intakes during pregnancy could increase the amount of weight gain above the optimal 25-35 pounds recommended for normal pregnancy and the amount of fat deposition that occurs during pregnancy.

A relatively new concept in studies regarding the influence of dietary fat intake on weight and body composition is the Food-Quotient (FQ). The FQ provides an overall indicator of macronutrient composition in the diet, but can also serve as a dietary standard because it takes into account caloric intake (17,19). Flatt (20) compares the FQ, the ratio of carbon dioxide produced to the oxygen consumed during the oxidation of the macronutrient mixture consumed, to the Respiratory Quotient (RQ), which is the ratio of carbon dioxide produced to oxygen consumed during actual metabolism (20). The FQ ranges from 0.7 (high-fat diet) to 1.0 (high-carbohydrate diet). Flatt (20) theorizes that an individual with a RQ higher than FQ will store fat due to inhibition of beta-oxidation, unless caloric intake is relatively low to metabolic needs, while an individual with a RQ lower than FQ will utilize fat stores due to increased beta-oxidation, perhaps, even if caloric intake matches energy expenditure. However, RQ does not need to be measured in order to interpret FQ (17,19). In a state of positive energy balance such as pregnancy, conceivably, individuals with lower FQs are more at risk for fat deposition. Whether this can be observed during pregnancy has yet to be shown.

If the relationship between dietary fat and body composition during pregnancy were more clearly understood, policies regarding diet composition during pregnancy could be developed and nutritional strategies could be implemented. This knowledge would allow physiological needs to be met during pregnancy without providing excess nutrients, thus decreasing the development of obesity postpartumly, and thereby decreasing or delaying the onset of chronic disease in females. Also, there is a paucity of research on the relationship

between the amount of weight gained during pregnancy and body fat deposition in individual pregnant women (21). Thus, this study was planned to: 1) assess body composition and dietary intake changes during pregnancy; and
2) examine the relationship between dietary intake and body composition during pregnancy.

METHODOLOGY

Subjects and Research Design

An analytic, observational study was performed to describe prospectively overall body composition changes during pregnancy and to assess the relationship of dietary intake to adiposity changes during pregnancy in a group of pregnant women. This study was approved by the Committee on Research Participation at the University of Tennessee, Knoxville. Caucasian females in the first trimester of pregnancy were recruited from local obstetric and gynecological clinics, in collaboration with a faculty member in the Department of Obstetrics and Gynecology at the University of Tennessee Medical Center. The subjects were prima or multiparous, in good health, and not edematous or classified as high risk pregnancies by their physician. All of the women had normal pregnancies throughout their participation in the study. Since impedance equations have been shown to underestimate percentage body fat in subjects who are obese (greater than 42% body fat) (22), only subjects with body fat of less than 40% participated in the study.

Measurements

NUTRIENT INTAKE

The Health Habits and History Questionnaire, which is the National Cancer Institute's self-administered, 98-item, semi-quantitative food frequency questionnaire, was used to estimate nutrient intake for the year prior to pregnancy and during each trimester (23). The validity and reliability of this questionnaire have been previously reported (23-25). There is little information available on normative portion sizes for pregnant females. However, previous research has found that limiting the choice on the food frequency questionnaire to the medium standard portion provides accurate estimates in females (23,26). Consequently, the portion sizes used on the questionnaire in this study were limited to the medium standard portion. A short section was added to the food frequency questionnaire to establish the overall health and diet patterns of the subjects. See Appendix A for the semi-quantitative food frequency questionnaire.

Subjects were asked to complete the questionnaire based upon health and diet patterns that occurred during the year prior to becoming pregnant. Additionally, subjects completed the same questionnaire for each trimester of pregnancy, based upon health and diet patterns that occurred during the month prior to administration of the questionnaire. Worsley (27) has reported that longer recall durations (past month, past 3 months, and past year) generally provide mean ratings similar in magnitude.

The National Cancer Institute's DIETANAL (28) software program was used to analyze the questionnaires to determine average macronutrient intake per day during each recall period. FQ was calculated from the average dietary intake information using the following formula (17,19):

FQ = (kilocalories as protein/total kilocalories X RQ protein) + (kilocalories as lipid/total kilocalories X RQ lipid) + (kilocalories as carbohydrate/total kilocalories X RQ carbohydrate);
with RQ protein = 0.8; RQ lipid = 0.7; and RQ carbohydrate = 1.0.

To assess the reliability of the food frequency questionnaire for measuring nutrient intake of this population, a random sample of 33% of the subjects completed a second food frequency questionnaire for at least one trimester of pregnancy. Subjects were instructed to return the completed questionnaire in a pre-addressed, pre-stamped envelope within a week of administration of the initial questionnaire. Coefficients of variation were calculated for kilocalories, and percent kilocalories from protein, fat, and carbohydrate only, as recommended by Delcourt et al. (29). Concurrent validity of the questionnaire was established by comparing the mean energy intakes for the first measurement (first trimester) to the mean energy intake of the second and third measurements (trimesters), calculating the mean difference, and then comparing this to the Recommended Dietary Allowances for energy intake for pregnancy. The first trimester, rather than the year prior to pregnancy, was selected to determine concurrent validity because not all of the subjects returned the food frequency based on the recall period of the year prior to pregnancy and the Recommended Dietary Allowances for energy intake during pregnancy do not increase until the second trimester of pregnancy.

ANTHROPOMETRIC DATA

Weight and Height

Weight was measured to the nearest 0.5 lb., using a Piezo electrical scale (Seca Model Integra 815, Seca Corporation, Columbia, MD), with subjects wearing light clothing without shoes. Height was measured to the nearest 0.1 inch, using a CDC-approved, portable stadiometer (Perspective Enterprises, Inc., Kalamazoo, MI), employing standard procedures (30). Measurements of anthropometric data were taken in triplicate, with the mean of the measurements used for data analysis.

Body Composition

To determine body composition, specifically fat mass, total body resistance (R) and reactance (Xc) were measured with a bioelectrical impedance analyzer (RJL model BIA-101, RJL Systems, Detroit, MI) that produces an imperceptible constant 800 *u*A alternating current at a fixed 50 KHz frequency (31). Subjects were in a fasted state (at least 2 hours postprandial) and did not engage in structured exercise or drink alcohol for at least 12 hours prior to bioimpedance measurement (31,32). Measurements were made with subjects lying in a supine position with limbs abducted at approximately 45° (31,33). All subjects were clothed, but without jewelry, shoes, and socks. Electrode contact areas were swabbed with isopropyl alcohol prior to electrode placement (31). The recommended right ipsilateral tetrapolar surface electrode technique was used (31). R and Xc measurements were recorded to the nearest ohm and were repeated in triplicate, with the mean of the measurements used to determine body impedance.

A specific equation determining fat mass (FM) in pregnant women by BIA has been previously developed (13). In that study, FM was measured by underwater weighing, using densitometric equations specific for pregnancy (13). Total body resistance (R) was also measured. Multiple regression revealed that weight (WT), in kilograms, and $height^2/R$, with height in centimeters, were the best predictors of FM, using the following equation: $FM\ (kg) = [-14.79 + 0.68(WT) - 0.246(height^2/R)]$ (13).

Protocol

All subjects were scheduled to receive three measurements, one during each trimester. The first measurement took place within the first trimester of pregnancy, the second measurement was scheduled between the 18th and 22nd week of pregnancy, and the third measurement was scheduled between the 30th and 34th week of pregnancy. This time frame for measurements during pregnancy has been used previously (34,35).

During the first measurement, demographic information (age, pregnancy, and gestational age) was obtained by self-report. After signing a consent form, the subjects completed the food frequency questionnaire using a recall period of the previous month. When the subjects completed the food frequency questionnaire, all measurements were taken. At the conclusion of the measurements, the subjects were given a food frequency questionnaire to complete using the recall period of the year prior to pregnancy along with information regarding nutrition and pregnancy (see Appendix B for the nutrition information provided at each measurement). Those subjects randomly selected to test the questionnaire's reliability were also given a food frequency questionnaire that was to be based upon the prior month of dietary intake. All subjects were instructed to complete the questionnaire(s) within a week and return it using a pre-addressed, pre-stamped envelope. If the questionnaire(s) was not returned within a week, subjects were reminded of the questionnaire(s) by phone, and a follow-up letter and another copy of the missing questionnaire(s) was sent if the subject did not respond within another week. All subjects received a copy of their dietary analysis, along with the results of their body composition analysis within two weeks of the date of measurement (see Appendix C for an example of the data subjects received).

For the second and third measurements, the subjects were contacted by phone to schedule an appointment during the appropriate measurement period. Reminder post cards were mailed to subjects (see Appendix D for reminder post card). All procedures for the second and third measurements were identical to the first measurement, except subjects did not have to complete a food frequency questionnaire based upon a recall period of the year prior to pregnancy.

Statistical Analysis

Data were analyzed with SPSS-PC+ on an IBM PS/2 computer (36). All variables were checked for normal distributions (skewness less than 1.3) and equal variances prior to performing parametric statistics. Variables were transformed as required. Non-parametric tests were used on data that did not meet criteria for parametric tests even after transformation.

All data were expressed as frequencies and means and standard deviations. Paired t-tests and Wilcoxon signed-ranks tests were performed to evaluate the differences in anthropometric and dietary variables between the first and second measurements. Repeated measures analysis of variance, using the multiple comparison test, Tukey's HSD, were used to analyze anthropometric and dietary data taken over the three measurements. Mauchly sphericity tests were conducted to assess if the repeated measures analysis of variance assumptions had been violated. When there was a violation in the assumptions, the Huynh-

Feldt Epsilon was used to adjust the degrees of freedom for averaged and difference test results.

Pearson product-moment correlation coefficients were calculated to assess the extent of linear associations among the principal variables of change in the study. Stepwise multiple regression analysis was used to ascertain the extent to which diet composition contributed to adiposity changes during pregnancy without statistically controlling for any potentially confounding variables. All statistical tests were two-tailed, except for those correlational tests which resulted in the direction of hypothesized change. Those correlational tests conducted as one-tailed tests were noted. A significance level of 0.05 was used for all statistical tests.

RESULTS

Subjects

Initially, 18 women were recruited to participate in the study, but due to difficulties in meeting testing schedules and personal considerations, 12 caucasian women participated in the study, with seven of the women completing all three measurements, and five of the women completing two of the three measurements. Table 1 lists the general characteristics of the subjects. Subjects' ages ranged from 20 to 42 years, with a mean age of 30.0 $\pm$ 6.5 years. Of the 12 subjects, 8 were primiparous, 2 had 2 children, and 2 subjects had 1

Table 1. Mean Characteristics of the Study Population[ab]

Variable	Description
Age (years)	30.0 ± 6.5
Parity	
Primiparous (%)	66.7
Multiparous (%)	33.3
Gestational Age (weeks)	
1st measurement	9.6 ± 3.3
2nd measurement	20.3 ± 1.3
3rd measurement	31.8 ± 1.4[c]
1st Trimester Body Mass Index	26.8 ± 6.0

[a]N=12
[b]Expressed as mean ± standard deviation
[c]N=7

child each. The range for gestational age for measurement 1 was the largest range of the three measurements, 11 weeks, extending from 4.5 to 15.5 weeks. This large range of gestational age for the first measurement was unavoidable since all subjects were measured shortly after their first prenatal visit. The range for gestational age for measurements 2 and 3 was 4.5 weeks, extending from 18.5 to 23 weeks and 30 to 34.5 weeks, respectively. The subjects' first trimester body mass index varied from 19.9 to 38.1, with a mean of 26.8 $\pm$ 6.0.

Measurements

NUTRIENT INTAKE DATA

Total energy, fat, carbohydrate, and protein intake were obtained from the food frequency and used to assess dietary intake and the relationship between dietary intake and body composition. Differences in nutrient intake were determined using only the results of the month food frequency questionnaires to coincide with differences in anthropometric measurements. Approximately 83% (n = 10) of the subjects returned the food frequency questionnaire assessing the dietary intake of the year prior to pregnancy. For the first, second, and third measurements' food frequencies, there was 100% compliance in completing the questionnaires, with 100% of the subjects completing the first two measurements and 58% of the subjects completing all three measurements. Consequently, the first and second measurements' food frequencies were based on a sample of twelve, and the third measurement's food frequency was based on a sample of seven.

Food Frequency Questionnaire for Year Prior to Pregnancy

In the year prior to pregnancy food frequency questionnaires, 50% of the subjects reported their current health as good or excellent, while 50% of the subjects reported their current health as fair. Also, 40% of the respondents indicated their overall dietary intake as typical, while 60% of the respondents indicated their overall dietary intake as not typical (30% indicated their overall dietary intake was more than usual, while 30% indicated their overall dietary intake was less than usual). The results of this questionnaire also showed that 50% of the respondents regularly took vitamin and mineral supplements in the year prior to becoming pregnant.

Macronutrient composition of dietary intake for the year prior to pregnancy is reported in Table 2. The mean kilocalorie intake for the year prior to pregnancy was 1859 $\pm$ 416, with a range of 1298 to 2779. The ranges for macronutrient composition of dietary intake were as follows: 1) protein - 69 to 156 total grams; 2) fat - 31 to 111 total grams (22% to 45% kilocalories from fat); and 3) carbohydrate - 192 to 324 total grams. The mean FQ for the year prior to pregnancy was 0.85 $\pm$ 0.04, with a range of 0.78 to 0.90.

Table 2. Dietary Intake of Subjects From the Year and Month Food Frequencies[a]

	Year Prior to Pregnancy[b]	Measurement 1[c]	Measurement 2[c]	Measurement 3[d]
Energy (kcals)	1859 $\pm$ 416	1840 $\pm$ 633	1861 $\pm$ 636	2023 $\pm$ 738
Protein				
(g)	80.4 $\pm$ 31.9	80.4 $\pm$ 36.9	81.9 $\pm$ 36.7	78.2 $\pm$ 29.9
(g/1000 kcals)	42.1 $\pm$ 6.8	42.4 $\pm$ 7.1	42.8 $\pm$ 6.7	38.8 $\pm$ 8.4
(% of kcals)	17.0 $\pm$ 2.7	17.0 $\pm$ 2.8	17.1 $\pm$ 2.7	15.5 $\pm$ 3.4
Fat				
(g)	65.5 $\pm$ 25.3	69.1 $\pm$ 21.4	67.5 $\pm$ 27.3	85.9 $\pm$ 49.8
(g/1000 kcals)	34.4 $\pm$ 7.7	38.7 $\pm$ 8.4	35.6 $\pm$ 7.5	40.2 $\pm$ 10.3
(% of kcals)	31.4 $\pm$ 7.3	34.8 $\pm$ 7.5	32.1 $\pm$ 6.8	36.2 $\pm$ 9.3
Carbohydrate				
(g)	224.3 $\pm$ 38.7	219.6 $\pm$ 92.2	231.1 $\pm$ 73.1	229.9 $\pm$ 56.5
(g/1000 kcals)	123.5 $\pm$ 21.4	118.1 $\pm$ 19.8	126.9 $\pm$ 20.1	118.1 $\pm$ 17.5
(% of kcals)	49.5 $\pm$ 8.5	47.2 $\pm$ 7.9	50.8 $\pm$ 8.1	47.3 $\pm$ 7.0
Food Quotient	0.85 $\pm$ 0.04	0.85 $\pm$ 0.04	0.87 $\pm$ 0.03	0.85 $\pm$ 0.02

[a]Expressed as mean $\pm$ standard deviation
[b]N=10
[c]N=12
[d]N=7

Month Food Frequency Questionnaire for Measurement 1

The results of this questionnaire indicated that 83% of the subjects felt that their current health was good or excellent, with the remaining 17% of the subjects stating that their current health was fair or poor. Only 25% of the subjects indicated that their dietary intake over the past week was typical, while 75% reported their dietary intake over the past week was atypical (50% stated their dietary intake over the past week was greater than usual, while 25% stated their dietary intake over the past week was less than usual). In regards to vitamin and mineral supplementation, 42% reported no use of supplements, 42% reported regular use of supplements, and 16% reported irregular use of supplements.

Table 2 reports the mean macronutrient consumption for the first measurement. The kilocalorie intake for the previous month was 1840 $\pm$ 633, with a range of 991 to 3153. The ranges for macronutrient composition of dietary intake for this questionnaire were as follows: 1) protein - 34 to 157 total grams; 2) fat - 38 to 93 total grams (22% to 44% kilocalories from fat); and 3) carbohydrate - 84 to 447 total grams. The mean FQ for the previous month was 0.85 $\pm$ 0.04, with a range of 0.75 to 0.89.

Month Food Frequency Questionnaire for Measurement 2

For this measurement period, 84% of the subjects reported their current health as good or excellent, with 16% reporting their current health as fair. Seventy-five percent of the subjects indicated their dietary intake over the past week was typical, while 17% reported eating less over the past week and 8% reported eating more over the same time. For vitamin and mineral supplemental use, 84% of the subjects reported regular use of supplementation, 8% reported no use of supplements, and 8% gave no answer.

The mean macronutrient consumption for measurement two is reported in Table 2. The kilocalorie intake for this time period ranged from 903 to 2953, with a mean of 1861 $\pm$ 636. For macronutrient composition of dietary intake, the following ranges were reported: 1) protein - 33 to 151 total grams; 2) fat - 18 to 101 total grams (18% to 42% kilocalories from fat); and 2) carbohydrate - 144 to 380 total grams. FQs for this time period ranged from 0.83 to 0.93, with a mean of 0.87 $\pm$ 0.03.

Month Food Frequency Questionnaire for Measurement 3

In regards to current health, 86% of the subjects reported their current health as excellent or good, while only 14% reported their current health as fair. Also, 86% of the subjects described their dietary intake in the past week as typical, while 14% of the subjects described their dietary intake in the past week as less than usual. For this measurement period, all subjects indicated they were regularly taking vitamin and mineral supplements.

Kilocalorie intake for this measurement period was 2023 $\pm$ 738, with a range of 1302 to 3159 (see Table 2 for means of macronutrient intake). Macronutrient composition of the diet for this time period varied as follows: 1) protein - 43 to 119 total grams; 2) fat - 38 to 161 total grams (24% to 49% kilocalories from fat); and 3) carbohydrate - 182 to 335 total grams. The mean FQ for this time period was 0.85 $\pm$ 0.02, with a range of 0.83 to 0.89.

Changes in Nutrient Intake from Measurement 1 to Measurement 2

Table 3 reports the mean changes in dietary intake between measurement one and measurement two. In general, the mean changes in dietary intake from measurement 1 to measurement 2 were small. Mean carbohydrate intake appeared to change the most between the two measurement periods. The mean changes in energy, protein, and carbohydrate intakes showed increased consumption, while the mean changes in fat intake showed decreased consumption. The mean change in FQ was very small, but did increase, indicating an increase in carbohydrate intake and a decrease in fat intake. In all instances the ranges of all the changes in nutrients showed variation.

Table 3. Changes in Dietary Intake of Subjects Over the Course of Pregnancy[ab]

	Δ Between Measurement 1 and Measurement 2[c]	Δ Between Measurement 2 and Measurement 3[d]	Δ Between Measurement 1 and Measurement 3[d]
Δ Energy (kcals)	21.3 ± 478.9	142.6 ± 928.7	423.2 ± 1007.4
Δ Protein			
(g)	1.5 ± 29.3	-1.4 ± 27.3	11.5 ± 40.6
(g/1000 kcals)	0.4 ± 7.8	-2.9 ± 6.2	-2.1 ± 10.3
(% of kcals)	0.1 ± 3.1	-1.2 ± 2.5	-0.8 ± 4.2
Δ Fat			
(g)	-1.6 ± 18.9	12.7 ± 58.3	15.9 ± 60.5
(g/1000 kcals)	-3.0 ± 5.9	1.7 ± 11.2	-3.5 ± 9.3
(% of kcals)	-2.7 ± 5.3	1.5 ± 10.1	-3.1 ± 8.4
Δ Carbohydrate			
(g)	11.5 ± 65.5	5.8 ± 80.8	56.9 ± 91.6
(g/1000 kcals)	8.8 ± 15.4	-2.9 ± 19.1	9.9 ± 11.1
(% of kcals)	3.5 ± 6.2	-1.2 ± 7.6	4.0 ± 4.4
Δ Food Quotient	0.02 ± 0.03	-0.01 ± 0.03	0.01 ± 0.03

[a]Expressed as mean ± standard deviation
[b]Statistical significance not shown in this table because it is a descriptive table.
[c]N=12
[d]N=7

Changes in Nutrient Intake from Measurement 2 to Measurement 3

Mean changes in dietary intake for measurement two to measurement three are reported in Table 3. Mean changes in energy and fat intake showed increased consumption of these nutrients. Energy emerged as the nutrient that changed the most between the two measurement periods. The mean changes in protein showed decreased consumption of protein, while the mean changes in carbohydrate revealed the total amount of grams of carbohydrate increased, but the percent of kilocalories and grams of carbohydrate per 1000 kilocalories decreased. The FQ mean change indicated a slight decrease in FQ, indicating an increase in fat consumption and a decrease in carbohydrate consumption. Again, in all instances the ranges of the changes in all the nutrients showed variability.

Changes in Nutrient Intake from Measurement 1 to Measurement 3

Table 3 documents the mean changes in dietary intake between measurement one and measurement three. Mean changes in energy and carbohydrate intake showed increased consumption of these nutrients during this time period. Both protein and fat mean changes in intake revealed overall increases in grams of fat and protein, but also revealed decreases in the percent of kilocalories from these macronutrients, as well as grams of these macronutrients per 1000 kilocalories. FQ mean change showed a slight increase in FQ, indicating an increase in carbohydrate intake and a decrease in fat intake. Again, in all instances the ranges of the changes in all the nutrients demonstrated variation.

Assessment of Concurrent Validity and Reliability

Concurrent validity of the food frequency questionnaire was conducted for subjects who completed all the measurements in the study. To establish concurrent validity of the food frequency questionnaire, the mean difference between the mean energy intake for the first measurement and the mean energy intake of the second and third measurements was compared to the Recommended Dietary Allowances for energy intake for pregnancy. The mean difference was 351 kilocalories. This is similar to the 300 kilocalorie increase recommended for the second and third trimester of pregnancy. Consequently, it appeared that concurrent validity was established.

To ascertain reliability, six of the food frequencies with recall periods of the past month were replicated. Those subjects who were assigned two food frequencies with recall periods of the same past month completed both questionnaires. The results were the following: 1) kilocalories - 8.4 $\pm$ 7.7 percent deviation (range = 0.1 - 21.0%); 2) protein - 5.5 $\pm$ 7.5 percent deviation (range = 0 - 20.3%); 3) fat - 5.0 $\pm$ 2.3 percent deviation (range = 0.8 - 7.4%); 4) carbohydrate - 4.1 $\pm$ 2.3 percent deviation (range = 0.4 - 8.0%). It appeared that subjects exhibited consistency in their responses to questions about dietary intake, indicating the food frequency questionnaire was reliable.

ANTHROPOMETRIC DATA

Measurements

Table 4 documents the anthropometric measurements for all three measurements. The mean weight of the subjects for the first measurement was 69.5 ± 14.0 kilograms (range = 49 to 91 kilograms). Body fat ranged from 10 to 35 kilograms, with a mean of 20.8 ± 8.2 kilograms. For the second measurement, the mean weight of the subjects increased to 72.0 ± 12.5 kilograms, with a range of 63 to 94 kilograms. Body fat also increased to a mean of 22.4 ± 7.1 kilograms (range = 14 to 37 kilograms). The mean weight of the subjects continued to increase to 80.7 ± 11.1 kilograms (range = 67 to 97 kilograms) in the third measurement. Body fat also proceeded to increase to a mean of 27.6 ± 6.6 kilograms, with a range of 18 to 39 kilograms.

Changes in Anthropometric Data Over All Three Measurements

Mean differences between the first and the second measurements and the second and the third measurements showed increased weight, body fat, and body fat percent, with the largest difference occurring between the second and the third measurements. Table 5 provides complete data on changes in

Table 4. Anthropometric Measurements of Subjects Over the Course of Pregnancy[a]

	Measurement 1[b]	Measurement 2[b]	Measurement 3[c]
Weight (kg)	69.5 $\pm$ 14.0	72.0 $\pm$ 12.5	80.7 $\pm$ 11.1
Height (cm)	161.4 $\pm$ 8.1	161.3 $\pm$ 8.2	162.1 $\pm$ 6.1
Body Fat (kg)	20.8 $\pm$ 8.2	22.4 $\pm$ 7.1	27.6 $\pm$ 6.6
Body Fat (%)	29.0 $\pm$ 5.8	30.5 $\pm$ 4.5	33.8 $\pm$ 4.1

[a]Expressed as mean $\pm$ standard deviation
[b]N=12
[c]N=7

Table 5. Changes in Anthropometric Measurements of Subjects Over the Course of Pregnancy[a]

	Δ Between Measurement 1 and Measurement 2[b]	Δ Between Measurement 2 and Measurement 3[c]	Δ Between Measurement 1 and Measurement 3[c]
Δ Weight (kg)	2.6 ± 2.3	5.2 ± 3.0	7.5 ± 5.4
Δ Body Fat (kg)	1.6 ± 1.7	3.2 ± 1.8	4.7 ± 3.3
Δ Body Fat (%)	1.5 ± 1.8	2.2 ± 2.0	3.5 ± 3.3

[a]Expressed as mean ± standard deviation
[b]N=12
[c]N=7

anthropometric measurements over the course of pregnancy. The difference between the first and the third measurement revealed a mean weight gain of 7.5 $\pm$ 5.4 kilograms, a mean body fat gain of 4.7 $\pm$ 3.3 kilograms, and a mean increase in body fat percent of 3.5 $\pm$ 3.3 %. While the vast majority of the subjects did gain weight and body fat, one subject who completed all three measurements concluded the study with a lower weight and amount of body fat than what was documented on the first measurement. This is not out of the norm for anthropometric changes seen in the clinic's population. Another subject who had only completed two measurements also had a lower weight and amount of body fat on the second measurement as compared to the first measurement. All other subjects showed increased weight, body fat, and body fat percent for each measurement.

LONGITUDINAL CHANGES IN DIETARY AND ANTHROPOMETRIC VARIABLES DURING PREGNANCY

Table 6 and Table 7 list the significant differences and trends in differences that approached significance in anthropometric and dietary variables between the first and second measurements and between all three measurements, respectively. Significant differences were found between the first and second measurement in weight ($p = 0.003$), body fat ($p = 0.009$), and body fat percent ($p = 0.013$), with all three variables increasing in amount by the second measurement. In regards to dietary differences between the first and

Table 6. Changes in Anthropometric and Dietary Variables that are Significant or Approach Significance: Comparison of Measurement 1 to Measurement 2[a]

	Measurement 1[b]	Measurement 2[b]	Statistical Significance
Weight (kg)	69.5 ± 14.0	72.0 ± 12.5	0.003 (t = -3.76)
Body Fat (kg)	20.8 ± 8.2	22.4 ± 7.1	0.009 (t = -3.18)
Body Fat (%)	29.0 ± 5.8	30.5 ± 4.5	0.013 (t = -2.94)
Dietary Fat (% of kcals)	34.8 ± 7.5	32.1 ± 6.8	0.104 (t = 1.77)
Dietary Carbohydrate (% of kcals)	47.2 ± 7.9	50.8 ± 8.1	0.071 (t = -2.00)
Dietary Fat (g/1000 kcals)	38.7 ± 8.4	35.6 ± 7.5	0.101 (t = 1.79)
Dietary Carbohydrate (g/1000 kcals)	118.1 ± 19.8	126.9 ± 20.1	0.072 (t = -1.99)
Food Quotient	0.85 ± 0.04	0.87 ± 0.03	0.099 (z = -1.65)

[a]N=12
[b]Expressed as mean ± standard deviation

Table 7. Changes in Anthropometric and Dietary Variables that are Significant or Approach Significance: Comparisons of Measurements 1, 2, & 3[a]

	Measurement 1[b]	Measurement 2[b]	Measurement 3[b]	Statistical Significance
Weight (kg)[c]	73.2 ± 14.0[d]	75.6 ± 12.8[e]	80.7 ± 11.1[f]	≤ 0.05 (F = 14.01)[g]
Body Fat (kg)[c]	22.9 ± 8.4[d]	24.4 ± 7.6[e]	27.6 ± 6.6[f]	≤ 0.05 (F = 13.81)[g]
Body Fat (%)[c]	30.3 ± 5.8	31.6 ± 4.8[e]	33.8 ± 4.1[f]	≤ 0.05 (F = 7.42)[g]
Dietary Carbohydrate (g)	173.0 ± 55.2	224.1 ± 58.1	229.8 ± 56.5	0.142[h] (F = 2.31)[g]
Dietary Carbohydrate (% of kcals)	43.3 ± 6.0	48.4 ± 4.8	47.3 ± 7.0	0.109[h] (F = 2.68)[g]
Dietary Carbohydrate (g/1000 kcals)	108.2 ± 14.9	121.0 ± 12.0	118.1 ± 17.5	0.110[h] (F = 2.67)[g]

[a]N=7
[b]Expressed as mean ± standard deviation
[c]Corrected degrees of freedom
[d]Statistical significance ($p \leq 0.05$) between measurement 1 & measurement 2
[e]Statistical significance ($p \leq 0.05$) between measurement 2 & measurement 3
[f]Statistical significance ($p \leq 0.05$) between measurement 1 & measurement 3
[g]Overall repeated measures ANOVA F statistic
[h]Overall repeated measures ANOVA p-level

second measurement, a propensity toward increasing percent of kilocalories from carbohydrate and grams of carbohydrate per 1000 kilocalories, along with decreasing percent of kilocalories from fat and grams of fat per 1000 kilocalories that approached statistical significance were noted. A trend in an increase in FQ was also noted, reflecting the previously mentioned changes in macronutrient consumption. No trends were found in total grams of macronutrient consumption or energy intake between the two measurements.

Significant differences were also found between all three measurements of weight ($p \leq 0.05$) and body fat ($p \leq 0.05$), showing a linear increase in these variables. Significant differences were also found between the second and third measurement and the first and third measurement for body fat percent ($p \leq 0.05$), again revealing increased body fat percent during the progression of pregnancy. For dietary intake, trends that approached statistical significance were found only regarding carbohydrate consumption. Total grams of carbohydrate intake increased over the course of pregnancy, while percent of kilocalories from carbohydrate and grams of carbohydrate per 1000 kilocalories showed a non-linear relationship during pregnancy. Between the first and second measurements these variables increased, but between the second and third measurements these variables decreased in amounts; however, they still remained higher than the first measurement. No trends were found in the other macronutrients or in energy intake over the course of the three measurements.

RELATIONSHIPS AMONG CHANGES IN ANTHROPOMETRIC AND DIETARY VARIABLES DURING PREGNANCY

Table 8 depicts a correlation matrix showing the interrelationships among the principal variables of change in this investigation between measurement one and measurement two. Pearson product-moment correlation coefficients revealed statistically significant positive correlations between weight change and body fat ($r = 0.87$, $p \leq 0.01$) and body fat percentage ($r = 0.88$, $p \leq 0.01$) change, as expected. A significant positive correlation was also found between body fat change and body fat percent change ($r = 0.90$, $p \leq 0.01$). Statistically significant positive correlations were also found between changes in energy intake and changes in grams of macronutrient composition. Of most interest was the statistically significant negative correlation of FQ changes with weight ($r = -0.51$, $p \leq 0.05$), body fat ($r = -0.77$, $p \leq 0.01$), and body fat percent ($r = -0.73$, $p \leq 0.01$) changes.

Table 9 delineates a correlation matrix for the key variables of change between measurement two and measurement three. A significant positive correlation was found between weight change and body fat change ($r = 0.68$, $p \leq 0.05$) and between body fat change and body fat percent change ($r = 0.92$, $p \leq 0.01$). Statistically significant positive correlations were also found between changes in energy intake and changes in grams of macronutrient composition. Interestingly, a significant positive correlation was found between changes in FQ and body fat percent change ($r = 0.84$, $p \leq 0.05$). A positive trend which

Table 8. Correlation Matrix Showing Relationships Between Key Change Variables: Measurement 1 to Measurement 2[a,b]

	Δ Wt (kg)	Δ Bf (kg)	Δ Bf (%)	Δ Ener (kcals)	Δ DPro (g)	Δ DFat (g)	Δ DCHO (g)	Δ FQ
Δ Weight (kg)	—	0.87**	0.88**	-0.09	-0.18	-0.23	-0.09	-0.57*
Δ Body Fat (kg)		—	0.90**	-0.22	-0.26	-0.35	-0.21	-0.77**
Δ Body Fat (%)			—	-0.19	-0.32	-0.30	-0.18	-0.73**
Δ Energy (kcals)				—	0.83**	0.81**	0.94**	0.21
Δ Dietary Protein (g)					—	0.71**	0.67**	0.16
Δ Dietary Fat (g)						—	0.61*	0.20
Δ Dietary Carbohydrate (g)							—	0.31
Δ Food Quotient								—

[a]N=12
[b]All statistically significant results were found with one-tailed tests
*$p \leq 0.05$
**$p \leq 0.01$

Table 9. Correlation Matrix Showing Relationships Between Key Change Variables: Measurement 2 to Measurement 3[a,b]

	Δ Wt (kg)	Δ Bf (kg)	Δ Bf (%)	Δ Ener (kcals)	Δ DPro (g)	Δ DFat (g)	Δ DCHO (g)	Δ FQ
Δ Weight (kg)	——	0.68*[c]	0.38	-0.54	-0.53	-0.51	-0.53	0.27
Δ Body Fat (kg)		——	0.92**	-0.37	-0.27	-0.42	-0.23	0.75[d]
Δ Body Fat (%)			——	-0.29	-0.19	-0.35	-0.14	0.84*
Δ Energy (kcals)				——	0.99**	0.99**	0.96**	-0.48
Δ Dietary Protein (g)					——	0.95**	0.99**	-0.36
Δ Dietary Fat (g)						——	0.91**	-0.59
Δ Dietary Carbohydrate (g)							——	-0.25
Δ Food Quotient								——

[a]N=7
[b]All statistically significant results were found with two-tailed tests except as indicated
[c]p-level is from one-tailed test
[d]p = 0.052 using a two-tailed test
*$p \leq 0.05$
**$p \leq 0.01$

approached significance was also found between changes in FQ and changes in body fat ($r = 0.75$, $p = 0.052$).

Table 10 depicts the correlation matrix for the key change variables for measurement one to measurement three. A statistically significant positive correlation was found between weight change and body fat change ($r = 0.83$, $p \leq 0.05$) and body fat change and body fat percent change ($r = 0.91$, $p \leq 0.01$). Statistically significant positive correlations were also found between changes in energy intake and changes in grams of macronutrient composition. In terms of the relationship between changes in dietary variables and changes in anthropometrics, only carbohydrate intake was related. A statistically significant negative correlation was found between body fat change and changes in grams of carbohydrate ($r = -0.69$, $p \leq 0.05$). A negative association which approached significance was also found between changes in FQ and changes in weight ($r = -0.66$, $p = 0.055$).

As shown in Table 11, multiple stepwise regression analysis revealed that for body fat changes that occurred between measurement one and measurement two, changes in weight and changes in FQ accounted for a significant amount of variation ($F = 28.52$, $r^2 = 0.83$, $p = 0.0001$). For body fat changes that occurred between measurement two and measurement three, changes in FQ, weight, and percent kilocalories from fat accounted for a significant amount of variation ($F = 10.11$, $r^2 = 0.82$, $p = 0.0446$). The only variable that accounted for a significant amount of variation in body fat changes that occurred from measurement one to measurement three was weight change ($F = 11.25$, $r^2 = 0.63$, $p = 0.0202$).

Table 10. Correlation Matrix Showing Relationships Between Key Change Variables: Measurement 1 to Measurement 3[a,b]

	Δ Wt (kg)	Δ Bf (kg)	Δ Bf (%)	Δ Ener (kcals)	Δ DPro (g)	Δ DFat (g)	Δ DCHO (g)	Δ FQ
Δ Weight (kg)	——	0.83*	0.61	-0.56	-0.44	-0.57	-0.58	-0.66[c]
Δ Body Fat (kg)		——	0.91**	-0.67	-0.49	-0.67	-0.69*[d]	-0.51
Δ Body Fat (%)			——	-0.64	-0.37	-0.67	-0.64	-0.15
Δ Energy (kcals)				——	0.89**	0.98**	0.99**	0.49
Δ Dietary Protein (g)					——	0.81*	0.92**	0.60
Δ Dietary Fat (g)						——	0.95**	0.45
Δ Dietary Carbohydrate (g)							——	0.50
Δ Food Quotient								——

[a]N=7
[b]All statistically significant results were found with two-tailed tests except as indicated
[c]p = 0.055 using a one-tailed test
[d]p level is from a one-tailed test
*$p \leq 0.05$
**$p \leq 0.01$

Table 11. Multiple Stepwise Regression Analysis of Factors Upon Change in Body Fat During Pregnancy

Independent Variables	Dependent Variable	F	r^2	p
Δ Between Measurement 1 and Measurement 2:[a]				
Δ Weight (kg) Δ Food Quotient	Δ Body Fat (kg)	28.52	0.83	0.0001
Δ Between Measurement 2 and Measurement 3:[b]				
Δ Food Quotient Δ Weight (kg) Δ Dietary Fat (%)	Δ Body Fat (kg)	10.11	0.82	0.0446
Δ Between Measurement 1 and Measurement 3:[b]				
Δ Weight (kg)	Δ Body Fat (kg)	11.25	0.63	0.0202

[a]N=12
[b]N=7

DISCUSSION

This study adds to the growing body of knowledge about dietary intake and body composition changes that occur during pregnancy. Since previous research has found a positive association with pregnancy and the occurrence of maternal adiposity, any additional information regarding possible factors that affect body composition changes during pregnancy is beneficial (37). With a better understanding of body composition changes during pregnancy and the factors that influence body composition changes during pregnancy, weight gain recommendations for pregnancy could be expanded to specify the amount and type of weight gain desired for optimum health during pregnancy. If more individualized recommendations could be made during pregnancy, the needs of the pregnant population would be better met.

Dietary Intake Over the Course of Pregnancy

From the results of the food frequency questionnaires, it appeared that overall feelings of health improved during the course of pregnancy, as did a feeling of having a "typical" dietary intake. This indicates that the first trimester of pregnancy is perhaps the most disruptive in terms of overall positive health feelings and dietary intake. These results are not surprising, considering that morning sickness is more pronounced in the first trimester of pregnancy.

Mean energy intakes over the course of pregnancy were found to be similar to what other studies have reported during pregnancy (21). The results of the dietary intake analysis showed that energy intake slightly dropped during the first trimester, as compared to prepregnancy energy intake, and then increased each trimester, with the greatest increase occurring between the second and third trimester. de Groot et al. (35), also found similar patterns of energy intakes over the course of pregnancy, however the overall energy intakes were approximately 200 kilocalories greater than those currently observed. de Groot et al. (35) also found a slight decrease in energy intake for the third trimester as compared to the second trimester, which was not found in this study. Celleir and Hankin (38) also found a decrease in energy intake in the third trimester of pregnancy as compared to the second trimester of pregnancy. An explanation for the different findings in the third trimester energy intake might be due to the differing time periods when the third trimester measurement was taken. It is assumed that energy requirements for pregnancy are the largest between the 10th and 30th week of pregnancy, consequently energy needs are highest in this period (21). The third measurement in this study, while taken in the third trimester, was around the 30th week of pregnancy (mean gestational age for the third measurement was 31.8 $\pm$ 1.4). This might explain why no decrease in energy intake was found in the third trimester; the measurement was taken still during, or very close to, the period of greatest energy requirements of pregnancy.

For macronutrient consumption, protein intake remained fairly stable over the course of pregnancy. A trend that approached statistical significance was found towards a decreasing intake of percent kilocalories from fat and grams of fat per 1000 kilocalories between the first and second trimesters, and an increase in percent of kilocalories from carbohydrate and grams of carbohydrate per 1000 kilocalories between the first and second trimesters, indicating that dietary fat and carbohydrate intake changed more dramatically than protein intake. Additionally, fat and carbohydrate intakes, in regard to percent of kilocalories and grams per 1000 kilocalories, did not follow a linear relationship over the course of the three measurements. Carbohydrate intake increased from the first to the second measurement, but then decreased from the second to the third measurement. FQ measurements mimicked the carbohydrate pattern of intake, while fat intake followed the inverse relationship. While trends that approached significance were found in some of these changes, none were found to be statistically significant. Celleir and Hankin (38) also found similar relationships between carbohydrate and fat intake.

Interestingly, van Raaij et al. (39) found that RQ increases during pregnancy, reaching a peak of 0.840 ± 0.059 during the 18th week of pregnancy, and then decreases to 0.819 ± 0.041 (which is slightly above the RQ of the first trimester of pregnancy, 0.812 ± 0.022) during the last 10 weeks of pregnancy. de Groot et al. (35) also found a lower RQ during the last 10 weeks of pregnancy (0.84 ± 0.01) as opposed to the 23rd week of pregnancy ($RQ = 0.85 \pm 0.02$). These RQs could indicate that during pregnancy, the body shifts to increase utilization of carbohydrates until sometime in the second trimester, perhaps around the eighteenth week of pregnancy. However, the decrease in RQ during the last ten weeks of pregnancy indicates the body begins to increase its utilization of fat during the last trimester (possibly to spare carbohydrate for the fetus), or at least in the last ten weeks of pregnancy. These results on RQ along with the results in FQ in this study indicate there may be a relationship between RQ and FQ changes in pregnancy which warrants further study.

Body Composition Over the Course of Pregnancy

Anthropometric measurements, weight and body fat, significantly increased during each measurement over the course of pregnancy, as has been reported many times (34,35,39,40). The largest increase in weight, body fat, and body fat percent was found between the second and third measurement (20th to 32nd week of pregnancy), which Villar et al. (34) has also reported. Interestingly, the amount of weight gain was found to be lower than previously reported (34), and if subjects continued to gain weight at the mean pace observed during the measurements, the mean final amount of weight gain would be only 9.4 kilograms (20.8 pounds). However, this amount of weight gain would be appropriate if the mean first trimester BMI, 26.8 $\pm$ 6.0, reflected pre-pregnancy BMIs for the sample studied (21). Mean body fat gain (4.7 $\pm$ 3.3 kilograms) was found to be higher than the 2-4 kilograms that has been previously reported (39,41). This larger amount of body fat gain shown in this study might be related to the timing of the third measurement; van Raaij et al. (39) reports that body fat mass decreases in the last trimester of pregnancy.

The Relationship Between Dietary Intake and Anthropometric Changes Over the Course of Pregnancy

Across the course of pregnancy, body weight and body fat changes were positively correlated. Thus, as expected, as weight increased, so did body fat accumulation.

Perhaps of greater importance is the significant associations found between FQ changes and anthropometric changes over the course of pregnancy. Between measurement one and measurement two, a significant negative correlation was found between the changes in weight, body fat, and body fat percent, and FQ. In this time period, the mean changes in FQ, weight, body fat, and body fat percentage were all positive (overall, all these factors were increasing). Therefore, this indicates that individuals who had a lower amount of increase in FQ change (indicating an overall lower FQ and a higher-fat, lower-carbohydrate diet) had a higher amount of increase in weight, body fat, and body fat percentage change. Since it appears, as previously discussed, that during this time period in pregnancy, the body shifts to utilizing slightly more carbohydrate, those individuals who do not increase their FQ to accommodate this shift, seem to increase the amount of change in weight, body fat, and body fat percentage. If this is true, these results would be in agreement with Flatt's theory on FQ (20). During the period between measurement two and measurement three, there again appeared to be an important relationship between changes in FQ and changes in body fat and body fat percent. In this time period, the mean change in FQ was negative, (overall FQ was decreasing), while the mean changes in body fat and body fat percent were positive (overall body fat and body fat percent were increasing). A significant positive correlation was found between changes in FQ and changes in body fat percent, and a positive association that approached statistical significance was found between changes in FQ and changes in body fat. These relationships tend to suggest that as there is more negative change in FQ (indicating an overall lower FQ and a higher-fat, lower-carbohydrate diet), there is more positive change in body fat percent and body fat change. If this time period in pregnancy does have a lower RQ, it would allow a higher fat intake to occur without as much fat deposition ensuing. However, if the negative change in FQ exceeds the decrease in RQ, fat deposition would continue.

Interestingly, there were no significant associations between FQ changes and anthropometric changes between measurement one and measurement three. When the period from the first to the third measurement was examined, the only significant relationship between dietary and anthropometric change variables was a negative correlation between change in total grams of carbohydrate intake and change in body fat.

Limitations

While this study found a significant relationship between anthropometric change and changes in dietary intake over the course of pregnancy, there are some limitations. The primary limitation of this study is the small sample size. However, other prospective studies regarding pregnancy have also had small, 15 subjects or less, sample sizes (35,40). With small samples, larger differences or associations are required in order to attain statistical significance, making it more difficult to achieve statistically significant results. Thus, many important trends were found in this study that only approached significance as a probable consequence of a small sample.

One confounding factor in the study is the potentiality of a small subpopulation of pregnant women who, over the total course of pregnancy, actually lose weight and body fat. These individuals, due to the loss of body weight and fat, might be responding differently to pregnancy than the larger population of pregnant women who gain body weight and fat during pregnancy. Since this study encountered a small percentage of subjects who lost weight and body fat, perhaps these individuals confounded the results, especially in regard to those analyses of the seven subjects who completed all three of the measurements, because one of the seven lost overall weight and body fat during the course of the study.

Another confounding factor in this study could be the high mean BMI in this study, which indicated that the subjects as a whole were overweight (BMI > 26.0). While the subjects were representative of the three primary classes of BMI for pregnancy, underweight, normal weight, and overweight, the mean BMI did fall into the overweight criteria. Overweight individuals may have dissimilar body composition changes than normal or underweight individuals during pregnancy and may respond differently to higher or lower levels of dietary fat and carbohydrate than those individuals who are not overweight.

Finally, changes in activity levels were not measured in this study. Since activity plays a significant part in energy expenditure, changes in activity may greatly affect changes in body weight and fat gain during pregnancy, even if dietary intake remains constant. Unfortunately, this factor was not controlled for in this study.

Recommendations

Recommendations for future research would be to continue research in this area with larger sample sizes, so excessive body fat gain during pregnancy can be defined. When excessive body fat gain during pregnancy is defined, logistic regression equations could be developed, thereby possibly making prediction equations for body fat changes that will occur during pregnancy.

More research needs to be performed in the area of anthropometric changes during pregnancy to identify if there is a subpopulation of pregnant women who lose overall weight and body fat over the course of pregnancy. Interestingly, it was found that 16.6% of the sample in this study demonstrated weight and fat loss during pregnancy. van Raaij et al. (39) found that 20% of their subjects showed a decline in fat stores during pregnancy. If there is a subpopulation, research regarding pregnancy should separate these two populations to determine where, when, how, and why the differences in the two pregnant populations are occurring. More research also needs to be conducted on anthropometric changes that occur during pregnancy in overweight women to determine if overweight and normal weight women respond to pregnancy differently, in terms of anthropometric changes.

To further establish the relationship between RQ and FQ and their effect on body composition changes during pregnancy, both RQ, FQ, and body composition need to be examined in a single study of pregnant women. This would help evaluate the usefulness of Flatt's (20) theory for pregnancy.

Finally, to determine the long-lasting effects of body composition changes during pregnancy, studies need to assess body composition after pregnancy. Studies need to appraise how much body fat gained during pregnancy remains at six months to one year after pregnancy, and if breastfeeding has an effect on body composition after pregnancy.

Summary

Significant anthropometric changes were encountered during the course of pregnancy, however a wide range of inter-individual variation was found. FQ, an overall indicator of macronutrient composition of the diet, was significantly associated with anthropometric changes during pregnancy. The associations between FQ and anthropometric changes during pregnancy suggested that a high-fat, low-carbohydrate diet was linked to greater weight gain and body fat deposition. Results of this study indicate that composition of the diet plays a role in weight and fat gain during pregnancy, indicating that a low-fat, high-carbohydrate diet during pregnancy might play a protective role against excessive weight and body fat gain during pregnancy.

Application

The results of this study suggest that energy intake and macronutrient composition of the diet is important for healthy body weight and fat gain during pregnancy. While an increase of 300 kilocalories for the second and third trimester of pregnancy is recommended to meet energy needs, this study suggests that the macronutrient composition of this 300 kilocalories, as well as the macronutrient composition of total energy intake is important during pregnancy. The Dietary Guidelines for Americans recommend to choose a diet low in fat ($\leq$ 30% kilocalories from fat) with plenty of vegetables, fruits, and grain products (high carbohydrate foods) (42). The results from this study imply that the Dietary Guidelines for Americans, in terms of a low-fat, high-carbohydrate diet, should be followed during pregnancy to help prevent excessive body weight and fat gain during pregnancy. Consequently, this indicates that healthy pregnant females should be counseled to maintain a dietary fat intake of $\leq$ 30% kilocalories and to have an adequate intake of vegetables, fruits, and grains.

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APPENDICES

APPENDIX A

SEMI-QUANTITATIVE FOOD FREQUENCY QUESTIONNAIRE

Code Number __________

Diet and Activity Questionnaire

This questionnaire includes a variety of questions about your activities and diet. Please read each question and complete as instructed. Please do not skip any questions. This information will be used, in part, to determine your current nutrient intake. A copy of this report will be sent to you within 2 weeks. Thank you for your time.

Section A. Activity and General Health

1. How would you rate your general health in the past week?

   a. Excellent
   b. Good
   c. Fair
   d. Poor

2. Which of the following statements best describes your diet in the past week?

   a. My diet has been fairly typical over the past week.
   b. I have been eating less than usual.
   c. I have been eating more than usual.

3. If your diet was NOT typical last WEEK, to what do you attribute it? (circle all that apply)

   a. I had morning sickness
   b. I did not feel well
   c. I did not have a typical week
   d. I was hungrier than usual
   e. Other

   Please describe how your answer(s) in #3 affected your diet?

4. Are you currently working?

   a. Yes
   b. No

   If yes, how much physical work is required on your job?

   a. A great deal
   b. A moderate amount
   c. A little
   d. None

5. How much physical work is required in your daily activities?

a. A great amount
b. A moderate amount
c. A little
d. None

6. Have you performed any physical activity, such as jogging, swimming, biking, etc., in the last 2 days?

a. Yes
b. No

If yes, what?____

If yes, when?____

Section B. Food Frequency and Diet History

7. During the past year, before your pregnancy, did you take any vitamins or minerals?

a. No (skip the rest of question #7 and go to question #8)
b. Yes, fairly regularly
c. Yes, but not regularly (skip the rest of question #7 and go to question #8)

What do you take fairly regularly? Fill in the number of pills per day or week in the following choices.

MULTIPLE VITAMINS		
One-a-day type	_____ pills per _____	
Stress-tabs type	_____ pills per _____	
Therapeutic, Theragran type	_____ pills per _____	
OTHER VITAMINS		How many mg or IU's per pill?
Vitamin A	_____ pills per _____	_____ IU per pill
Vitamin C	_____ pills per _____	_____ mg per pill
Vitamin E	_____ pills per _____	_____ IU per pill
Calcium or dolomite	_____ pills per _____	_____ mg per pill
OTHER PILLS		
Yeast	_____ pills per _____	
Zinc	_____ pills per _____	
Beta-carotene	_____ pills per _____	
Selenium	_____ pills per _____	
Iron	_____ pills per _____	
Cod liver oil	_____ pills per _____	
Other __________	_____ pills per _____	

Please list the brand of multiple vitamin/mineral you usually take __________________________

8. Have you drank any alcohol (wine, beer, mixed drinks, etc.) in the past 24 hours?

a. Yes
b. No

9. This section is about your usual eating habits. Thinking back over the past MONTH, how often did you usually eat the food listed on the next pages? Read each food item and decide if you have eaten the food item during the past MONTH. We have included many foods commonly eaten but no one eats all of the foods listed all of the time!

If you have eaten a food during the past MONTH, look at the serving size. A medium serving is listed and you should adjust the number of servings if you typically ate or drank smaller or larger amounts of the food. A small portion is about one-half the medium serving size. A large portion is about one and a half times to two times as much as the medium serving size.

Then think about how often you ate the food during the past MONTH. If you did not eat the food during the past MONTH, put a check in the box marked RARELY/NEVER. If you ate the food every day, or 1-6 times per week, or 1-3 times per month, think about HOW MANY times you ate the food ON AVERAGE and write the number in the box under Day, Week, or Month.

For example, you may eat bananas twice a week (put a 2 in the "Week" column). If you never eat the food, check "Rarely/Never". Please do not skip foods. Please be careful as to which column you put your answer in. It will make a big difference if you say "hamburger once a day" when you mean "hamburger once a week!" Some items say "in season." Indicate if you ate these foods during the past MONTH.

Please look at the example below. This person ate:

1. A medium serving of cantaloupe once a week
2. A 1/2 grapefruit about twice a month
3. A large hamburger or cheeseburger or meatloaf about four times a week
4. Did not eat winter squash during the past MONTH

EXAMPLE:

		How Often?			
	Medium Serving	Day	Week	Month	Rarely/Never
Cantaloupe (in season)	1/4 medium		1		
Grapefruit	1/2			2	
Hamburger, cheese-burger, meatloaf	1 medium		4		
Winter squash	1/2 cup				√

FRUITS & JUICES	Medium Serving	How Often? Day	Week	Month	Rarely Never
EXAMPLE - Apples, applesauce, pears	(1) or 1/2 cup		4		
Apples, applesauce, pears	(1) or 1/2 cup				
Bananas	1 medium				
Peaches, apricots (canned, frozen or dried, whole year)	(1) or 1/2 cup				
Peaches, apricots, nectarines (fresh, in season)	1 medium				
Cantaloupe (in season	1/4 medium				
Watermelon (in season)	1 slice				
Strawberries (fresh, in season)	1/2 cup				
Oranges	1 medium				
Orange juice or grapefruit juice	1 oz. glass				
Grapefruit	(1/2)				
Tang, Start breakfast drinks	6 oz. glass				
Other fruit juices, fortified fruit drinks	6 oz. glass				
Any other fruit, including berries, fruit cocktail	1/2 cup				

VEGETABLES	Medium Serving	How Often? Day	Week	Month	Rarely Never
String beans, green beans	1/2 cup				
Peas	1/2 cup				
Chili with beans	3/4 cup				
Other beans such as baked beans, pintos, kidney beans, limes	3/4 cup				
Corn	1/2 cup				
Winter squash, baked squash	1/2 cup				
Tomatoes, tomato juice	(1) or 6 oz.				
Red chili sauce, taco sauce, salsa picante	2 Tblsp. sauce				
Broccoli	1/2 cup				
Cauliflower or brussel sprouts	1/2 cup				
Spinach (raw)	3/4 cup				
Spinach (cooked)	1/2 cup				
Mustard greens, turnip greens, collards	1/2 cup				
Cole slaw, cabbage, sauerkraut	1/2 cup				
Carrots, or mixed vegetables containing carrots	1/2 cup				
Green salad	1 med. bowl				
Salad dressing, mayonnaise (including on sandwiches)	2 Tblsp				
French fries and fried potatoes	3/4 cup				
Sweet potatoes, yams	1/2 cup				
Other potatoes, including boiled, baked, potato salad	(1) or 1/2 cup				
Rice	3/4 cup				
Any other vegetable, including cooked onions, summer squash	1/2 cup				
Butter, margarine or other fat on vegetables, potatoes, etc	2 pats				

MEAT, FISH, POULTRY & MIXED DISHES	Medium Serving	How Often? Day	Week	Month	Rarely Never
Hamburgers, cheeseburgers, meat loaf	1 medium				
Beef-steaks, roasts	4 oz.				
Beef stew or pot pie with carrots, other vegetables	1 cup				
Liver, including chicken livers	4 oz.				
Pork, including chops, roasts	2 chops or 4 oz				
Fried chicken	2 sm. or 1 lg. piece				
Chicken or turkey, roasted, stewed or broiled	2 sm. or 1 lg. piece				
Fried fish or fish sandwich	4 oz. or 1 sand.				
Tuna fish, tuna salad, tuna casserole	1/2 cup				
Shell fish (shrimp, lobster, crab, oysters, etc.)	(5) 1/4 cup or 3 oz.				
Other fish, broiled, baked	4 oz.				
Spaghetti, lasagna, other pasta with tomato sauce	1 cup				
Pizza	2 slices				
Mixed dishes with cheese (such as macaroni and cheese)	1 cup				

4

LUNCH ITEMS	Medium Serving	How Often? Day	Week	Month	Rarely Never
Liverwurst	2 slices				
Hot dogs	2 dogs				
Ham, lunch meats	2 slices				
Vegetable soup, vegetable beef, minestrone, tomato soup	1 med. bowl				
Other soups	1 med. bowl				

BREADS/SALTY SNACKS/SPREADS	Medium Serving	How Often? Day	Week	Month	Rarely Never
Biscuits, muffins, burger rolls (incl. fast foods)	1 med. piece				
White bread (including sandwiches), bagels, etc. crackers	2 slices, 3 cracks				
Dark bread, including whole wheat, rye, pumpernickel	2 slices				
Corn bread, corn muffins, corn tortillas	1 med. piece				
Salty snacks (such as chips, popcorn)	2 handfuls				
Peanuts, peanut butter	2 Tblsp.				
Butter on bread or rolls	2 pats				
Margarine on bread or rolls	2 pats				
Gravies made with meat drippings, or white sauce	2 Tblsp				

BREAKFAST FOODS	Medium Serving	How Often? Day	Week	Month	Rarely Never
High fiber, bran or granola cereals, shredded wheat	1 med. bowl				
Highly fortified cereals, such as Product 19, Total, or Most	1 med. bowl				
Other cold cereals, such as Corn Flakes, Rice Krispies	1 med. bowl				
Cooked cereals	1 med. bowl				
Sugar added to cereal	2 teaspn.				
Eggs 1 egg = small	2 eggs = medium				
Bacon	2 slices				
Sausage	2 patties or links				

SWEETS	Medium Serving	How Often? Day	Week	Month	Rarely Never
Ice cream	1 scoop				
Doughnuts, cookies, cakes, pastry	1 pc. or 3 cookies				
Pumpkin pie, sweet potato pie	1 med. slice				
Other pies	1 med. slice				
Chocolate candy	small bar, 1 oz.				
Other candy, jelly, honey, brown sugar	3 pc. or 1 Tblsp				

DAIRY PRODUCTS	Medium Serving	How Often? Day	Week	Month	Rarely Never
Cottage cheese	1/2 cup				
Other cheeses and cheese spreads	2 slices or 2 oz				
Flavored yogurt	1 cup				
Whole milk and bevs. with whole milk (not incl. on cereal)	8 oz. glass				
2% milk and bevs. with 2% milk (not incl. on cereal)	8 oz. glass				
Skim milk, 1% milk or buttermilk (not incl. on cereal)	8 oz. glass				

BEVERAGES	Medium Serving	How Often? Day	Week	Month	Rarely Never
Regular soft drinks	12 oz. can or bottle				
Diet soft drinks	12 oz. can or bottle				
Beer	12 oz. can or bottle				
Wine	1 med. glass				
Liquor	1 shot				
Decaffeinated coffee	1 med. cup				
Coffee, not decaffeinated	1 med. cup				
Tea (hot or iced)	1 med. cup				
Lemon in tea	1 teaspn.				
Non-dairy creamer in coffee or tea	1 Tblsp.				
Milk in coffee or tea	1 Tblsp.				
Cream (real) or Half-and-Half in coffee or tea	1 Tblsp.				
Sugar in coffee or tea	2 teaspn.				
Artificial sweetener in coffee or tea	1 packet				
Glasses of water, not counting in coffee or tea	8 oz. glass				

Think about your diet over the past year and the responses you have made on this questionnaire. Are there any foods not mentioned which you ate at least once a week, even in small quantities, or ate frequently in a particular season? Consider other meats, breakfast foods, catsup, green chilies, or jalapenos, avocado (guacamole), Mexican Dishes, Chinese or other ethnic foods, other fruits or vegetables, as well as nutritional supplements (bran, etc.). Please take a look at the list of foods below.

DO YOU EAT THESE ONCE A WEEK?

veal, lamb	01	pancakes	21	onions	41	Hi-C	63
tofu	03	instant breakfast	22	summer squash	42	cranberry juice cocktail	64
mixed dish w/meat	04	pudding	23	asparagus	43	grapes	65
mixed dish w/chicken	05	milkshake	24	sweet green peppers	44	mangoes	66
Chinese dishes	06	other dairy product	25	sweet red peppers	45	papayas	67
Mexican dishes	07	other dessert, sweet	26	bean sprouts	46	honeydew or cassava melon	68
seafood creole	08	sour cream, dips	31	avocado, guacamole	47	lemons or lemon juice	69
refried beans or bean burritos	09	diet salad dressing	32	beets	48	nuts and seeds	70
Polish or Italian sausage	10	catsup	33	pineapple or pineapple juice	61	bran	71
cream soups	11	green chilies, jalapenos	34	prunes or prune juice	62	other vegetable/fruit	79
noodles	12					other/not mentioned here	88

FOOD	Your Serving Size S	M	L	How Often? Day	Week

	1 Seldom/Never	2 Sometimes	3 Often/Always
How often do you eat the skin on chicken?	______	______	______
How often do you eat the fat on meat?	______	______	______
How often do you add salt to your food?	______	______	______
How often do you add pepper to your food?	______	______	______

How often do you use fat or oil in cooking (for example, for frying eggs, meat, or vegetables)?

_______ times per _______ (day, week, month)

What do you usually cook with?

____ Don't know or don't cook (1)
____ Soft margarine (2)
____ Stick margarine (3)
____ Butter (4)
____ Oil (5)
____ Lard, fatback, bacon fat (6)
____ Pam or no oil (7)

What kind of fat do you usually add to vegetables, potatoes, etc.?

____ Don't add fat (1)
____ Soft margarine (2)
____ Stick margarine (3)
____ Butter (4)
____ Half butter, half margarine (5)
____ Lard, fatback, bacon fat (6)

Not counting salad or potatoes, about how many vegetables do you eat per day or week?

____________ per ____________
vegetables day, week

Not counting juices, how many fruits do you usually eat per day or per week?

____________ per ____________
fruits day, week

APPENDIX B

NUTRITION INFORMATION PROVIDED TO SUBJECTS

NUTRITION INFORMATION FOR MEASUREMENT 1

NUTRITION DURING PREGNANCY

Practicing good nutrition during pregnancy will give your baby a healthier start in life. By continuing to make wise food choices, you will influence your infant's growth and development and the health of your entire family.

Ideally, good nutrition begins before you become pregnant. The woman who enters pregnancy well nourished has adequate body reserves of nutrients and usually fewer complications than the malnourished woman.

Although you cannot change your past, it is never too late to establish new and improved dietary habits.

Nutrients for You and Your Baby

Your baby needs additional protein, minerals, vitamins and calories for proper development. Careful selection of a variety of foods can provide these important nutrients.

Protein

Protein forms the basic structure of every cell of the body. This essential nutrients helps build and maintain tissues. Quality of protein, as well as quantity, is important. Animal sources of protein, such as meat, eggs, milk, and cheese, provide a higher quality protein than legumes, nuts, and grains. However, the quality of plant protein is improved when served with animal protein at the same meal, such as when cereal and milk are combined. A daily mixture of animal and plant sources of protein is desirable.

Iron

Iron requires special attention. Both you and your growing baby needs extra iron, especially in the latter half of the pregnancy. The baby stores this iron for needs during the first few months of life. Because the amount of iron needed in pregnancy is difficult to obtain from food intake alone, some doctors prescribe an iron supplement during pregnancy. Even though you may be taking iron medication, continue to eat foods that are good sources of iron.

Liver and other organ meats are excellent sources of iron. Lean meats and dried beans, such as pinto, navy, or garbanzo, provide protein as well as iron. You absorb vitamins A and C along with iron when you eat "greens". Choose whole-grain or enriched breads and cereals and the varieties fortified with iron. Try dried fruits as snacks. Snacks with important nutrient, not just calories, help feed your baby properly now. They help you meet your iron needs after delivery.

Calcium

Calcium is the main component of bones and teeth. Although teeth begin to form as early as six to eight weeks in utero, the need for calcium is most critical during the last three months of pregnancy, when fetal bone formation takes place. If the mother's diet does not supply enough calcium, her bone stores will be sacrificed to meet the needs of the developing fetus.

Dairy products and canned salmon or sardines with bones are excellent sources of calcium. If you have difficulty drinking the recommended **four** glasses of milk each day, you may substitute creamed soups and milk-based desserts, such as custard and pudding. Cheese, yogurt, and other dairy products can also replace milk in the diet. Try adding powdered milk to cereals, ground meats, and other foods to increase milk intake.

Vitamin D

Vitamin D is essential for the body to use calcium efficiently. While vitamin D naturally occurs in small amounts in a few foods, it can be supplied by spending time in the sun each day.

Vitamin D is added to "fortified" milk and some margarines as well as some cereals. Fish liver oils are the best natural source of this vitamin.

Other Vitamins and Minerals

A variety of foods will provide other important nutrients, such as vitamins A and C and the eleven B vitamins you will need during pregnancy. Your doctor may also prescribe a supplement for you, because you need extra iron and folacin during pregnancy. The regular use of iodized salt is recommended due to increased urinary losses of iodine and added metabolic demands for this mineral.

Other foods

Your food diary may contain foods not specified in the food groups. These foods may include candy, soft drinks jellies, jams, salted chips, cake, pastries, and gravies that add variety and additional calories. If you eat too many of them, you may be replacing foods containing essential nutrients. Evaluate your food diary. If necessary, cut down on the "other foods". Include nutrient-rich foods before adding "others".

Snacks

Snacks count in determining how well your eating habits score nutritionally. Choose snacks that count toward the daily food pattern. Cheese pizzas can provide part of the protein. Replace chips with nuts to add protein. Substitute citrus or other juices for soft drinks and pick up important vitamins.

Snacks that cannot be counted as milk, meat, fruit-vegetable, or whole-grain should be added to the diet only after your nutrient requirements are met through the recommended daily servings of these foods and only if your calorie need has not been met.

Lipids

The usual recommended liquid intake is six to eight glasses daily. This includes such fluids as milk, juice, and water. Other liquids can be included, but use in moderation those with caffeine content, such as colas, coffee, and tea.

Eating for 2: Your Daily Food Guide

Food	Servings	Serving Size/Examples of Foods
Protein-rich foods		
Milk, cheese and yogurt	4 or more	1 cup milk or yogurt 2 ounces cheese 1 cup cottage cheese
Meat, poultry, fish, and alternatives	3	3 ounces cooked lean meat, fish, poultry 1 egg 1/2 cup cooked dried beans or peas 2 tablespoons peanut butter 1/2 cup tofu
Carbohydrate vitamin and mineral-rich foods		
Grains, whole or enriched breads, or cereals	6 or more	1 slice bread 1 muffin or bagel 1/2 English muffin 1/2 cup cooked cereal, pasta, or rice 1 ounce ready-to-eat cereal
Vegetables		
Dark-green leafy or deep yellow	3 or more, including (1 or more)	1 cup raw or 1/2 cup cooked
Vitamin C-rich vegetables: tomato, broccoli, sweet peppers, potato	(1 or more)	1 cup raw or 1/2 cup 1 medium-sized baked potato
Other vegetables	1 or more	1 cup raw or 1/2 cup cooked
Fruits		
Vitamin C-rich fruits: citrus melon, berries	2 or more, including (1 or more)	3/4 cup juice 1/2 grapefruit whole organ 1 cup berries 1 melon wedge
All other fruits	1 or more	1 medium piece 1/2 cup cooked or canned fruit 1/4 cup dried fruit

NUTRITION INFORMATION FOR MEASUREMENT 2

MANAGEMENT OF COMMON DISCOMFORTS DURING PREGNANCY

Heartburn

A natural slowing of digestion during pregnancy causes reduction of the stomach emptying of acidic gastric juices. When these juices bubble back up into your esophagus, a burning sensation, called heartburn, results. Heartburn arises in the stomach area and spreads to the throat. It is aggravated by the upward displacement of the stomach as your uterus grows. Nervous tension, fatigue and improper diet can all contribute to the intensity of this discomfort.

For prevention and relief of heartburn, try these adjustments:

- Eat small, frequent meals.
- Avoid fried and fatty foods.
- For evening heartburn, avoid eating two hours before bedtime; elevate the head of your bed.
- Avoid highly spiced or very rich foods.
- Antacid preparations (Gelusil, Maalox) may be taken without consulting your physician. Follow directions on the label.

Gas Formation (Flatus)

Formation of gas, due to bacterial action in the intestine, is fairly common and can be uncomfortable. Decreased movement of the intestinal tract slows the normal functioning of the bowel causing gas accumulation.

- Eat small amounts of food and chew it well.
- Avoid gas-forming foods: beans, corn, fried foods, pastry, heavy desserts.
- Establish a regular bowel movement pattern.
- Exercise regularly.

Constipation

The decreased muscle tone and motility of your large bowel causes constipation. Use of iron and vitamin supplements prescribed for you during pregnancy can also aggravate this condition.

- Establish regular bowel movement pattern.
- Maintain a large fluid intake (6-8 glasses of liquid each day).
- Exercise regularly.
- Include in your diet fresh fruits, raw vegetables, whole grain breads and cereals.

Mild laxatives, such as Milk of Magnesia, can be taken as needed. Follow directions on the printed label.

Hemorrhoids

Several symptoms result from pressure of your growing uterus on blood vessels in the lower part of your body. Among these are hemorrhoids, varicose veins, and leg cramps.

Hemorrhoids are enlarged, blood-filled veins that protrude from the rectum. In some cases, hemorrhoids are inside the rectum as well. Discomforts associated with hemorrhoids include itching, bleeding and pain.

- To help prevent hemorrhoids, avoid constipation (see above).
- Avoid sitting or standing for long periods of time.
- For relief, use Preparation H® or Tucks® ointment.
- Cold compresses or application of an ice bag may relieve discomfort.

In cases of severe symptoms, contact your physician, who may prescribe additional medication.

NUTRITION INFORMATION FOR MEASUREMENT 3

From the pamphlet, "Breastfeeding is Easy to Learn."

How Do I Start Breastfeeding My Baby In The Hospital?

- Tell the nurses you want to breastfeed.
- Ask a nurse to help you learn how to breastfeed.
- Start to breastfeed as soon after delivery as you can.
- Keep your baby in the room with you both day and night, if hospital rules permit. This is called rooming-in.
- Ask for breastfeeding supplies, like breast pads and a breast pump, if needed (you will need a pump if you or your baby is ill and unable to nurse or your breasts have too much milk).
- Ask for the name and telephone number of a breast-feeding counselor or someone who can answer your questions about breastfeeding.

What Do I Need To Know When I Start Breastfeeding?

- Feed your baby whenever he or she seems hungry. Don't forget to feed your baby during the night, too.

How Do I Hold My Baby While Breastfeeding?

- Choose the position that is most comfortable for you.
- It is good to use different positions.
- These pictures will show you some of the positions you can use:

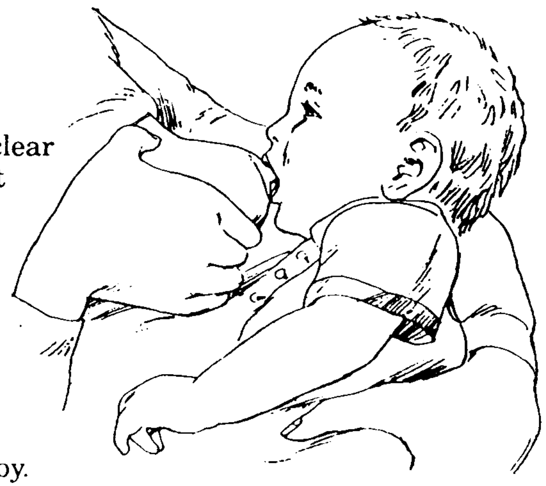
- You should nurse every two hours, and try to give your baby at least eight feedings every day and night. The more you nurse in the first few days, the better it is for you and your baby.
- Feed your baby only breast milk for the first few weeks.
- Don't give your baby formula.
- Don't give your baby water. (You won't need to if your pregnancy was full term.)
- You will feel sore from delivery, but don't let this stop you from nursing. If you are very sore after birth (from a tubal or Caesarean), ask your doctor for medication that will help you with the pain and let you keep breastfeeding.

What Will It Be Like The First Time I Breastfeed?

- At first, you will have a thick yellow or clear and watery milk called "colostrum" that helps protect your baby from infection.
- Colostrum is the mother's first milk. It provides the best nutrition for your baby's first days of life. Colostrum will last 24–72 hours (one to three days).
- Your milk will come in after the colostrum.
- Relax. Take time to get to know your baby.

How Do I Start Nursing?

- Bring your baby close to your breast.
- Hold your breast in your hand and stroke the baby's lips with the nipple until the baby's mouth opens wide. Then pull the baby onto your breast.
- Have the baby take in as much of the dark part (areola) as possible with his or her mouth.
- Hold the baby close while nursing.
- If your nipple is sore, try nursing with the baby in a different position. Soreness is often due to incorrect sucking – don't stop nursing...do ask for help.
- Take a few deep breaths to help you relax.
- Nurse your baby on both breasts at each feeding.



- After you finish nursing on each breast, burp your baby. He or she may not burp after every feeding.
- To remove your baby from your breast, place your finger at the corner of your baby's mouth to break the suction. Or press your finger down on your breast close to your baby's mouth.
- The next time you breastfeed, start nursing your baby on the same breast your baby finished nursing on last time. A safety pin on your bra is a good way to remember which breast to use first.

APPENDIX C

DIETARY AND BODY COMPOSITIONAL DATA PROVIDED TO SUBJECTS

Department of Nutrition
University of Tennessee
1215 W. Cumberland Ave.
Knoxville, TN 37996-1900

Dear :

Enclosed are the results of your dietary intake and your body composition analysis for your second trimester of pregnancy. The report on the results of your dietary intake is four pages. This report includes your average daily nutrient intake on page 1; your percent of total calories from fat, protein, and carbohydrate and food group intake on page 2; and foods that you eat that contribute to a large portion of your caloric, fat, saturated fat, dietary fiber, and vitamin and mineral intake. Page 4 reports the RDAs, recommended dietary allowances, for your stage of pregnancy. Please use page 4 as your recommended range rather than those reported on page 1.

We have also enclosed the results of your body composition analysis. The results are reported in total kilograms of body fat, as well as percentage of body fat.

If you have not returned any of your questionnaires, please do so at this time. If you have any questions regarding this information, your participation, or if you need another pink questionnaire, please call Hollie Raynor or Paula Zemel at 974-5445. Thank you for your participation.

Sincerely,

Hollie Raynor
Public Health Nutrition Graduate Student

DIET QUESTIONNAIRE SUMMARY FOR INVESTIGATOR

Respondent ID: 000000 SEX: FEMALE AGE: 99
Standard portions as printed on questionnaire have been used.

The following nutrient values are estimates based on reported frequency of consumption and portion sizes on the diet questionnaire. Nutrients from vitamin supplements are reported separately.

AVERAGE DAILY NUTRIENTS			Recommended Ranges
TOTAL CALORIES	1864.4	CALORIES	Depends on Age, Sex, Activity
CALORIES EXCLUDING ALCOHOLIC BEVERAGES	1864.4	CALORIES	Depends on Age, Sex, Activity
PROTEIN	74.7	GRAMS	.36 grams per Lb Body Wt
TOTAL FAT	97.6	GRAMS	Under .034 x Non-Alcohol Cals
CARBOHYDRATE	173.8	GRAMS	.125 - .150 x Non-Alcohol Cals
CALCIUM	874.9	MG	Age 11-24 or pregnant: 1200. 25+:800
PHOSPHORUS	1236.1	MG	Age 11-24 or pregnant: 1200. 25+:800
IRON	12.3	MG	Men: 10 mg Women: 15 mg
SODIUM	3348.7	MG	500-2400 mg
POTASSIUM	2872.6	MG	2000-3500 mg or more
VITAMIN A (IU)	13341.0	I.U.	Men: 5000 I.U.; Women: 4000 I.U.
VITAMIN A (RE)	1694.9	RE	Men: 1000; Women: 800
THIAMIN (B1)	1.4	MG	Men: 1.5 mg; Women: 1.1 mg
RIBOFLAVIN (B2)	1.8	MG	Men: 1.7 mg; Women: 1.3 mg
NIACIN	16.1	MG	Men: 19 mg; Women: 15 mg
VITAMIN C	157.9	MG	60 mg, more for optimum. Smoker 100+
SATURATED FAT	33.5	GRAMS	Approx. 1/3 of fat
OLEIC ACID	36.9	GRAMS	Approx. 1/3 of fat
LINOLEIC ACID	18.7	GRAMS	Approx. 1/3 of fat
CHOLESTEROL	360.0	MG	Less than 300 mg
DIETARY FIBER	14.7	GRAMS	20-30 grams
FOLATE	293.8	MCG	Men: 200;Women 15-50 yr:400, 51+ 180
VITAMIN E	12.0	a-TE	Men: 10; Women: 8 mg a-TE
ZINC	9.4	MG	Men: 15 mg; Women: 12 mg
ZINC FROM ANIMAL	6.5	MG	Men: 15 mg; Women: 12 mg
VITAMIN B6	1.3	MG	Men: 2 mg; Women: 1.6 mg
MAGNESIUM	251.0	MG	Men: 350 mg; Women: 280 mg
ALPHA-CAROTENE	223.3	MCG	A carotenoid, no range set
BETA-CAROTENE	8942.5	MCG	A carotenoid, no range set
CRYPTOXANTHIN	150.7	MCG	A carotenoid, no range set
LUTEIN	17284.7	MCG	A carotenoid, no range set
LYCOPENE	7131.2	MCG	A carotenoid, no range set
RETINOL	541.1	MCG	Preformed Vit. A, approx. 500-800
PRO-A CAROTENES	6925.5	MCG	Vit A carotenoids, approx. 1500-2000

% Calories Excluding Alcoholic Beverages		Recommended Ranges
From Fat:	47.1%	LESS THAN 30 PERCENT
From Protein:	16.0%	10-12% (more if over age 60)
From Carbohydrate:	37.3%	50-60%

Percent of Total Calories	
From Fat:	47.1%
From Protein:	16.0%
From Carbohydrate:	37.3%
From Sweets:	5.0%
From Alcohol:	0.0%

GROUPED FOODS	FREQUENCY (PER DAY)	RECOMMENDED SERVINGS
Vegetable group	4.7	3-5 Servings
Fruit and fruit juice group	1.0	2-4 servings
Bread, cereal, rice & pasta	2.7	6-11 servings
Milk, yogurt and cheese group	1.5	2-3 servings
Meat,poultry,fish,beans,eggs	2.3	2-3 servings
Fats, oils, sweets, & snacks	2.8	Use sparingly
Alcoholic Beverages	0.0	In Moderation

Average Daily Intake of Vitamins from Supplements:

Vitamin A:	0.0 I.U.
Vitamin C:	0.0 mgs
Vitamin D:	0.0 I.U.
Vitamin E:	0.0 a-TE
Iron:	0.0 mgs
Calcium:	0.0 mgs
Zinc:	0.0 mgs
B-Carotene:	0.0 mcgs*
Thiamin:	0.0 mgs
B6:	0.0 mgs
B12:	0.0 mcgs
Folate:	0.0 mcgs
Copper:	0.0 mgs

Other Vitamin: None Stated

* - Not all brands of multiple vitamins contain beta-carotene.

TOP SOURCES

TOTAL CALORIES	
BISCUITS, MUFFINS	330.00 CALORIES
2 % MILK	144.55 CALORIES
WHITE BREAD, ROLLS	135.50 CALORIES
TOTAL FAT	
BISCUITS, MUFFINS	18.20 GRAMS
SOFT MARGARINE	11.20 GRAMS
MAYONNAISE, SALAD DRESSINGS	8.23 GRAMS
SATURATED FAT	
BISCUITS, MUFFINS	7.58 GRAMS
2 % MILK	3.19 GRAMS
CHEESE AND CHEESE SPREAD	2.47 GRAMS
DIETARY FIBER	
TOMATOES AND TOMATO JUICE	3.63 GRAMS
SPINACH (COOKED)	2.41 GRAMS
BISCUITS, MUFFINS	1.45 GRAMS
VITAMIN C	
TOMATOES AND TOMATO JUICE	55.66 MG
ORANGE JUICE, GRAPEFRUIT JUICE	51.02 MG
SPINACH (COOKED)	14.33 MG
PRO-A CAROTENES	
SPINACH (COOKED)	3706.90 MCG
TOMATOES AND TOMATO JUICE	1645.12 MCG
CARROTS, MIXED VEG WITH CARROTS	584.76 MCG
ZINC	
HAMBURGER,BEEF BURRITO,MEATLOAF	1.30 MG
BEEF (FAT NOT TRIMMED OFF)	0.96 MG
2 % MILK	0.96 MG
FOLATE	
SPINACH (COOKED)	81.08 MCG
ORANGE JUICE, GRAPEFRUIT JUICE	46.55 MCG
TOMATOES AND TOMATO JUICE	22.75 MCG
VITAMIN E	
SOFT MARGARINE	1.76 a-TE
SPINACH (COOKED)	1.43 a-TE
MAYONNAISE, SALAD DRESSINGS	1.40 a-TE
VITAMIN B6	
TOMATOES AND TOMATO JUICE	0.12 MG
SPINACH (COOKED)	0.11 MG
OTHER POTATOES	0.11 MG

Recommended Dietary Allowances (RDAs) for Second Trimester of Pregnancy

The RDAs are the levels of intake of essential nutrients that, on the basis of scientific knowledge, are judged by the Food and Nutrition Board to be adequate to meet the nutrient needs of practically all active, healthy persons. The RDAs are to be used as guides and not as absolutes.

Energy	2,500 calories
Protein	60 grams
Vitamin A	800 μg RE
Vitamin D	10 μg
Vitamin E	10 mg α-TE
Vitamin K	65 μg
Vitamin C	70 mg
Thiamin	1.5 mg
Riboflavin	1.6 mg
Niacin	17 mg NE
Vitamin B_6	2.2 mg
Folate	400 μg
Vitamin B_{12}	2.2 μg
Calcium	1200 mg
Phosphorus	1200 mg
Magnesium	320 mg
Iron	30 mg
Zinc	15 mg
Iodine	175 μg
Selenium	65 μg

BODY COMPOSITION

Body fat = 27.33 kilograms (60.1 pounds)

Body fat % = 33%

APPENDIX D

REMINDER POST CARD

HELLO

This is a reminder for your appointment.

WHEN:______________________

WHERE:______________________

FOR:______________________

Call Hollie Raynor at 984-1126 if you
have changed your appointment with the
doctor or if you have any questions.

Department of Nutrition
University of Tennessee
1215 W. Cumberland Avenue
Knoxville, TN 37996-1900

NAME:______________________

ADDRESS:______________________

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VITA

Hollie Anne Raynor was born on June 11, 1967, in San Antonio, Texas. She received the degree of Bachelor of Science in Family Studies and Consumer Sciences with a major in Food and Nutrition and a minor in Personality and Social Psychology from San Diego State University in 1992. In August of 1995, she received a Master of Science degree in Nutrition with a minor in Public Health.