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Date April 6, 1993

The Relationship Between Dietary Fat and Body Composition During Pregnancy, as Reported by a Self-Administered Semiquantitative Food Frequency Questionnaire and Underwater Weighing

A Thesis

Presented for the

Master of Science

Degree

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Stacey Lee Krawczyk

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DEDICATION

This thesis is dedicated to my loving husband, Thomas, who without his unending support and patience, this manuscript and my entire graduate education could not have been completed.

Thank you!

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ABSTRACT

The purpose of this study was to examine if a relationship existed between dietary fat intake and body composition during pregnancy, as reported by a self-administered semiquantitative food frequency questionnaire and underwater weighing. Thirty-eight pregnant women (28.6 ± 6 years) completed two food frequency questionnaires, using two retention intervals: dietary intake during the year before pregnancy, and dietary intake during the previous month of pregnancy. Height, weight and underwater weight were obtained using standard procedures. The mean gestational age was 25 ± 9 weeks (55.3% primaparous) with 7, 10, and 21 subjects in each of the successive trimesters. Pre-pregnancy body mass index (PPGBMI) , mean of 26.4 ± 6, was calculated using self-reported pre-pregnancy weights. There was a significant 223 kcal increase ($p < 0.01$) from pre-pregnancy to the pregnancy dietary intakes. The composition of macronutrients, however, did not significantly differ between pre-pregnancy and pregnancy intakes. The mean pregnancy percent dietary fat intake was $36.8\pm8\%$. The mean pregnancy body fat percentage was 30.2 ± 6.5. This was correlated to PPGBMI at 0.71 ($p < 0.001$), month dietary fat percentage at 0.39, and year dietary fat percentage at 0.31. A backward multiple stepwise regression analysis found that parity, PPGBMI and month percent dietary fat ($F = 10.9$, $R^2 = 0.53$, $p < 0.0001$), were significant predictors for the dependent variable of pregnancy body fat percentage. These results indicate that body fat deposition during pregnancy may be influenced by dietary fat intake, as well as other pregnancy related variables. Further research with larger sample sizes is needed to substantiate these results.

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CHAPTER I

INTRODUCTION

The concept of obesity development in association with pregnancy was studied first by Sheldon in 1949 (1). Postpartum residual weight may be due to factors either directly related to the pregnancy itself, or as a result of the change in lifestyle associated with having children (2).

One of the factors related directly to pregnancy could be the amount of calories in the diet, as well as the corresponding composition of macronutrients. Dietary fat intake during this time, therefore, might possibly have an impact on the amount of weight gain and body fat deposition for women (3).

Optimal weight gain during a normal pregnancy has been established at 25-35 pounds by the 1990 Institute of Medicine's report, *Nutrition During Pregnancy* (4). The report also suggested that more studies are needed to determine if there is a relationship between the amount of weight gained during pregnancy and body fat deposition in individual women (4).

It is not always easy to assess factors associated with human pregnancy by experimental methods. If the effects of various dietary constituents were understood more clearly, policies regarding the composition of the diet could be formulated and educational programs developed. This would allow physiological needs to be met without providing excess nutrients, which could prevent excess residual weight and decrease the woman's risk of chronic disease later in life.

The food frequency method of measuring dietary intake has been used to measure the diets of different populations. This method has been found to provide valid and reliable results when used during pregnancy (5,6).

Thus, the purpose of this study is to examine if a relationship exists between dietary fat and the body composition changes during pregnancy, as reported by a self-administered semiquantitative food frequency questionnaire and underwater weighing.

Justification

Shah et al (7) found a significant increase in women's body mass index and the prevalence of obesity from 1980-1987. This has a powerful influence with respect to the development of risks associated with several chronic diseases.

Postpartum residual weight can increase the waist to hip (W/H) ratio and body mass index (BMI) in women. Tonklaar et al (8) 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 (8,9).

Forester et al (10) found a positive association between number of births and body mass index among white women, independent of sociodemographic characteristics. This strong association suggests that number of births may account in part for postpartum weight gain in white women (10). Newcombe (11) also found that parity had an effect on obesity development.

Dietary fat plays a major role in weight gain and the development of hypertriglyceridemia (9). In addition, dietary fat has been shown to be positively associated with the risk of developing colon cancer (13). Thus, there may be chronic health problems that extend beyond the short-term effects of pregnancy.

Consequently, learning more about the role dietary fat plays in weight gain during pregnancy may be very important to those interested in the prevention of such chronic problems. This might also impact weight gain recommendations. If a link can be established between dietary fat and body fat during positive energy balance states, dietary guidance given during such states can be modified.

CHAPTER II

REVIEW OF LITERATURE

Maternal Obesity

As previously mentioned, Sheldon (1) was one of the first to recognize the development of obesity in postpartum women. Recent studies have focused more on the changes in body composition associated with pregnancy that can increase such indices as BMI and W/H ratios (2,8-11). These subsequent increases can lead to the development of chronic diseases which significantly impact the quality of life.

In a study done by Shah et al (7) secular trends in BMI and obesity were examined over a seven year period. They found that women had an increase in BMI of 0.19 kg/m^2/year versus the BMI increase in men of 0.08 kg/m^2/year, when adjusted for age and education. In addition, prevalence of obesity (defined as $\geq$ 85^{th} percentile at Year 1) increased by 1.0 percent per year in women. This study was done on upper mid-western adults, but data from three nationwide surveys in 1960-1980 support the fact that there is an overall increase in the prevalence of overweight in women.

Shah et al (7) suggest that not only is the female population as a whole getting "fatter," but the prevalence of severe obesity is accelerating more rapidly. This rise in obesity may be a result of factors solely related to having children, or in combination with the dietary and exercise habits of Americans.

Researchers in The Netherlands studied a large sample of women over the age of 40 years to assess their W/H ratios (8). They found that fat distribution is associated positively with parity and current smoking habits in premenopausal and postmenopausal women. As the number of children increased, the W/H ratio and Quetelet's index (BMI) also increased.

In a study done by Forster et al (10) the reproductive histories and BMI of black and white women were investigated. This was the first study that looked at the relationship of obesity and childbearing in the United States. They found that there was a strong association between number of births and BMI, independent of age, in white women. This suggests that number of births may account for, in part, the residual weight gain associated with pregnancy.

Obesity development has many factors as previously illustrated. One component of weight gain, in addition to other dietary factors, could be the amount of dietary fat that a person consumes. By understanding the influence of dietary fat on whole body composition, the relationship to developing obesity, and hence chronic disease, may be ascertained.

Body Composition Assessment

A review article by Lukaski (12) lists all the methods that have been used to determine body composition. Research to establish indirect methods of determining human body composition began in the 1940's. Most methods are based upon the model that divides the body into two distinctive parts, the fat and fat-free compartments (16).

A study done by Forsum et al (14) estimated body fat in 29 Swedish women during pregnancy. They used six different skinfold thickness measurements, with specific equations for pregnancy. They found there was no correlation between changes in body weight and body fat during the complete pregnancy. However, the authors stated that the results are very imprecise since equations developed for one study are not necessarily valid when applied to subjects in another study, as they were in this case. Thus, estimates of body composition changes during reproduction using skinfold techniques should be interpreted with caution.

New densitometry equations for pregnancy were developed by van Raaij et al (15) in a Dutch study of 42 pregnant women. The authors determined body composition by the method of underwater weighing.

For determining body composition, skinfold measurements are very commonly used in the field, but have questionable accuracy for use during pregnancy (14). Underwater weighing is considered the standard for body composition measurements (12). New equations developed by van Raaij et al (15) allow underwater weighing to become a viable option in assessing body composition in pregnancy. By measuring body composition prospectively, changes in fat mass can be observed.

Dietary Fat Implications

There have been many studies that have assessed the influence dietary fat has on body weight and composition. In a review by Rolls and Shide (17) the authors state that high fat foods do promote the development of obesity. In addition, they note that as body fat increases, the percentage of energy derived from fat also increases.

Thomas et al (18) studied the affect of diet composition on the regulation of body weight. By feeding 10 women high fat and high carbohydrate diets for one week each, it was suggested that high fat diets were more obesity-producing than high carbohydrate diets. The diet composition was fixed, but the calorie intake was unrestricted and higher on the high fat diet.

A recent study by Slattery et al (19) investigated the associations between body fat and its distribution with several factors in 5115 young adults. Their results indicated that protein was directly associated with body mass index, even after adjusting for confounders, and waist to hip ratios were positively associated with total kilocalories in women. The authors concluded that dietary composition may be associated with both the amount of total body fat and distribution of fat within the body.

Sheppard et al (20) examined the weight changes of 303 women over one and two years. These women were participating in a low-fat dietary intervention trial. They found that weight loss was more strongly associated with the change in percent energy from fat than with the change in total kilocalories. This suggested that body fat is a function of both energy balance and percent of kilocalories from fat.

An intervention study done in Sweden found that by attending dietary classes and participating in an exercise program, abdominally obese women (BMI $\geq$ 30 and/or W/H ratio of $\geq$ 0.82) were able to make significant changes in their body compositions (9). They significantly reduced their body weight, BMI, waist circumference, and W/H ratio as compared to a group of corresponding non-participants. Their triglyceride levels also were reduced by 21% compared to the controls (9).

Miller et al (21) examined the relationship among body fat, dietary composition, energy intake and exercise in 109 female adults. The authors used underwater weighing to determine body composition and a food frequency, plus two-day food records, to assess dietary intake.

Miller et al (21) found there was a 0.81 correlation of body fat with body weight in females. A 0.37 correlation between body fat and dietary fat, significant at the $p<0.001$ level, was found also in the women. They concluded that as body fat increased, the percent energy from fat also increased, whereas body fat had an inverse relationship with percent energy from carbohydrate. There was no relationship of energy intake to adiposity. Their data suggested that body fat is related to diet composition and exercise activity rather than to energy intake. Therefore, diet composition could play a role in fat deposition.

Tucker and Kano (22) also examined the relationship of dietary fat with body fat in 205 females. They used the National Cancer Institute's *Health Habits and History Questionnaire* by Block to assess dietary intake and skinfold-thickness to assess body fat. Even with controlling for such confounders as age, total energy intake, total exercise, and smoking, the intake of dietary fat was related significantly with adiposity. The authors recommended that more research, however, is needed in this area, especially in states of positive energy balance.

Emerson et al (3) were the first researchers able to separate the influence of dietary intake on whole body composition from that of the normal physiologic adjustments of pregnancy. Throughout their pregnancies, three normal women and two women with diabetes were hospitalized for one week each month. At these times they were placed on measured diets of constant composition approaching their customary food intake as closely as possible, except that in all instances daily protein intake exceeded 75 grams.

Emerson et al (3) found that in normal pregnancy the storage of body fat is regulated by the energy content of the diet just as in the non-pregnant female. If caloric intake is restricted, so is fat accumulation and vise versa.

If dietary fat was found to be the major contributor to body fat and "excess fat" in the diet could be defined, what impact would this have on the positive energy balance state of pregnancy? Could the diet composition then be adjusted so that physiological needs would be met without providing "excess fat?" This might then decrease the fat accumulation that occurs during pregnancy. If this is the case, less residual fat might decrease the prevalence of the development of obesity which would then decrease the risks for developing chronic diseases.

Dietary Trends in the United States

National surveys on dietary consumption patterns allow researchers to assess trends in the American population. Thompson et al (23) recently reported, according to the 1985-1986 Continuing Survey of Food Intakes by Individuals (CSFII 85-86), women are consuming more than the recommended intakes for fat. The study included data from 2134 women aged 19 to 50 years. Although the percent energy derived from fat has decreased from 40.8% in 1977-78 to 36.8% in 1985, this does not meet the Dietary Guidelines recommendation of less than 30% of calories from fat.

Popkin et al (24) also compared the CSFII from 1977 to the study in 1985. The authors identified that these women had increased their intakes of high fat cheeses, desserts and high fat mixed grains. These trends contribute to the overall pattern of higher fat and lower fiber intakes.

Georgiou and Arquitt (25) found the same trends in a study of 199 undergraduate women enrolled in introductory nutrition courses. The greatest contributors to per capita fat intake were found to be the higher fat desserts, cheeses and grain mixtures also reported in the CSFII 85-86.

Another study using 1985 CSFII survey data was conducted by Haines et al (26). The eating patterns of 1,120 women aged 19-50 years were examined based on whether the meals were consumed at home or at one of seven away-from-home locations. Their results indicate that where you eat has an impact on fat intake. Those who were in the "Fast Food" pattern consumed the highest total fat intake. Those in the "Restaurant" pattern consumed the highest fat density. The "Home Mixed" pattern of the moderately educated, middle-aged and middle-income females was the most healthful of all the patterns.

Many different methods can be used to provide dietary intake data. To be able to compare fat intake versus body deposition, the composition of the diet must be determined first. The amounts and types of food a person consumes can be analyzed to discover the percentage of macronutrients that contribute to the diet.

Assessing Dietary Composition

A variety of methods have been developed and used to assess the dietary intake of individuals. Block et al (27) developed a self-administered semiquantitative diet history questionnaire based on dietary data from 11,658 people in the Second National Health and Nutrition Examination Survey (NHANES II from 1976-1980). This is the National Cancer Institute's Health Habits and History Questionnaire (NCI Block). Validation of the questionnaire, using one day diet records, produced an overall correlation of 0.70, and a correlation of 0.74 with fat. The food list contains 94.7% of the foods that represent the total fat intake in respondents on the NHANES II. Foods were included on the questionnaire if they made an important contribution to the population's intake of energy and contained each of the 17 nutrients in the NHANES II database.

Portion sizes on the questionnaire were listed as small, medium and large. The subject chose both the portion size and frequency of the foods. Block et al (27) found that limiting the choice to the standard medium portion size produces accurate estimates in females.

Block et al (28) later used a modified version of the questionnaire in a validation study using the mean of 277 four day diet records, of women ages 45-70 years, collected over the year prior to administration of the questionnaire. They found that the control group had the same percentage of calories from fat (37.7%) as measured by the food records and the questionnaire. The intervention group (low fat diet) had 21.3% calories from fat as measured by the food records and 23.7% as measured by the questionnaire. The correlations between questionnaire and diet records for percent of calories from fat were 0.67 and 0.65 respectively in the two groups. Most correlations of other nutrients were in the 0.5-0.6 range, and were similar to those achievable by a single four day food record (28).

Recently Block et al (29) reported another validation study comparing two different dietary history questionnaires, the NCI Block and the University of Michigan questionnaires. The reference data consisted of the mean of four-day food records collected the year before the administration of the questionnaire. The sample consisted of 85 black and white women and men aged 25 to 50 years. The authors found the University of Michigan questionnaire consistently overestimated nutrients when compared to the food records. The Block et al questionnaire produced correlations of 0.58 with fat, 0.62 for energy, 0.56 for protein, and 0.68 for carbohydrate.

In a study done by Krall and Dwyer (30), the authors evaluated the validity of the NCI Block food frequency questionnaire and a food diary in a short-term recall situation. The 19 participants were monitored in a metabolic research facility for 14 days. The food served was from a three day cycle menu and was weighed before it was presented to the participant. Subjects completed a 3 day food diary and one food frequency questionnaire each week based on the food they had received in the facility. Results indicated that all nutrients were significantly underestimated by the food frequency.

In contrast, Willett et al (31) validated a self-administered semi-quantitative food frequency questionnaire by comparing results with a one year diet record of 27 subjects taken 18 months prior to the administration of the questionnaire. They found that the questionnaire estimates of the mean nutrient intakes were within 10% of the mean diet record measurements for 11 of 18 nutrients evaluated. The difference was less than 25% for all but one nutrient. The correlation coefficient for total fat was 0.76 and those for saturated fat, polyunsaturated fat, and cholesterol all were greater than 0.65. The overall mean correlation coefficient of the 18 nutrients measured by the questionnaire and by the diet record was 0.60. This suggests that the food questionnaire can provide information on dietary intake over an extended period of time.

Several studies have used a "modified" version of an already established food frequency questionnaire (28,29,31). Modification results in the use of a standardized portion size as the "medium," rather than asking the subject to pick from small, medium and large portion sizes.

Hunter et al (32) investigated whether the limitations to just the medium portion size introduced any errors. Their results indicated that the use of the standard medium portion size may not introduce large errors in establishing the food and nutrient intakes of women.

Although food frequencies are a helpful tool in assessing dietary intakes, they are not without their criticisms. In a commentary by Sempos (33), the author stated that while the correlations of greater than 0.60 on food frequencies may be good, a few random 24 hour recalls or multiple food records may provide a better estimate of an individual's absolute intake.

Flegal and Larkin (34) found that the quantitative food frequency questionnaire underestimated the mean percent calories from fat and protein, and overestimated the mean percent derived from carbohydrate when compared to 16 days of food records for each subject. However, these correlations were higher than if absolute amounts were compared. Their recommendations were to use percent of macronutrients instead of absolute amounts.

In a recent article by Briefel et al (35), the limitations of the NCI Block food frequency were discussed. The authors stated that the food frequency questionnaire developed by Block et al used dietary data from 1976-1980 to develop the food list and portion sizes. Also the portions are not well defined due to the use of broad categories of foods. Lastly, the food frequency has limited use since it is not culturally sensitive. They suggest using the food frequency in a homogeneous population rather than for use in collecting national survey data.

Zulkifli and Yu (36) noted that originally the food frequency method of dietary assessment was designed to describe dietary patterns or habits rather than nutrient intakes. Upon reviewing the literature, the authors concluded that for best validity and reliability, the food frequency is best left for ranking or monitoring patterns over time. Additionally, macronutrients were found to be more highly correlated with energy. This may suggest that food frequencies are better utilized for determining macronutrients, compared to other nutrients.

The food frequency does have limitations in its use. However, when used in the assessment and ranking of a homogeneous population's diet, it appears that good validity and reliability can be established to enable the comparisons of dietary intakes.

Dietary Assessment in Pregnancy

Rush and Kristal (37) studied the problem of the reliability of quantitative historical estimation of nutrient intake during pregnancy in 520 low-income black women. Their conclusions suggest that the repeated 24 hour recall is a reliable measure for large scale studies in pregnancy.

In a study done by Endres et al (38) the dietary intakes of 63 older low-income pregnant women over 35 years and 526 pregnant adolescents were assessed by 24-hour recall. It was found that the older women were more likely to be obese prior to the pregnancy. As for dietary intake, both groups consumed less than the RDA for energy.

A comparison of food frequency and diet recall methods in studies of nutrient intake of low-income pregnant women was studied by Suitor et al (5). The authors developed a self-administered semiquantitative prenatal food frequency questionnaire to assess the intakes of this population. The portion sizes were assigned to each food item on the basis of median portion size in grams reported for women 19 to 29 years of age in the NHANES II. The authors concluded their questionnaire did provide useful data about recent intake of selected nutrients, but overestimation of foods occurred among up to 20% of this population. They suggested that a food frequency questionnaire targeted toward pregnant women should collect data about recent intake and about changing appetite and food habits.

Suitor et al (6) also studied a group of 335 low-income culturally diverse pregnant women in Massachusetts. They used the Prenatal Food Frequency Questionnaire for calculating an Index for Nutritional Quality in these women's diets. Nutrients focused on were energy, protein and micronutrients.

Of the studies just discussed, all used food intake measurements taken on low-income pregnant women. They assessed micronutrients, protein and energy intake to identify those who were not consuming the RDA for those nutrients. Dietary fat was not assessed, and there was no discussion of the implications of overconsumption during pregnancy. This suggests that there is a need to study pregnant women and assess the effects of overconsumption and dietary fat.

A few studies have shown that pregnant women do make changes in their diets (39,40). There is more motivation to decrease the intake of alcohol and caffeine, and to quit or cut down on smoking during pregnancy. If dietary fat was found to be correlated with body fat during pregnancy, pregnant women may be more willing to select a healthy diet that meets energy needs, but without consuming excessive fat.

Summary

It has been established that pregnancy does have an effect on body composition and possibly the development of obesity. Dietary fat has been found to play a role in development of obesity. Therefore if the relationship among these factors were better understood, the part they play in the development of maternal obesity might be understood as well. In addition, weight gain recommendations could be expanded to specify the amount and type of weight gain based on body composition. The linkage of dietary fat to the corresponding body composition would allow dietary recommendations to be made as well.

CHAPTER III

METHODS

Purpose

The purpose of this study is to examine the relationship between dietary fat and body composition during pregnancy, as reported by a self-administered semiquantitative food frequency questionnaire and underwater weighing.

Hypothesis

The hypothesis of this study is that self-reported dietary fat is associated positively with fat storage in human pregnancy.

Research Design

In order to answer this question, an analytical study was designed to obtain data from a cross-sectional group of subjects. The dietary fat intake of the subjects was estimated by the National Cancer Institute's semiquantitative food frequency questionnaire developed by Block et al (27). The dietary fat intake was compared to the percent body fat arrived at by underwater weighing, using the pregnancy calculations developed by van Raaij et al (15).

Limitations of this particular design could include the small number of subjects, the cross-sectional design, and the possible recruitment of unequal numbers within the trimesters. While this study was meant to be initial research, these particular limits might affect the generalizability of the results.

Methods

Description of Subjects. The study was conducted with the approval of the Committee on Research Participation at the University of Tennessee, Knoxville. Pregnant women were recruited from local obstetric and gynecological clinics and from the greater Knoxville area. This was through cooperation with attending physicians and advertisements placed in local newspapers. The subjects were prima or multiparous, in good health, not presenting with current edema and not classified as a high risk pregnancy by their physician. A signed consent form was obtained from each subject. All data were collected at the Health, Physical Education and Recreation Building on the campus of the University of Tennessee, Knoxville.

Sample Size Estimation. The number of subjects needed to address the hypothesis was estimated using the method of Kraemer and Thiemann (41). The calculations were done assuming a correlational model, a power of 0.9, and a one-tailed significance level of 0.05.

Food Frequency Questionnaire Modification. The National Cancer Institute's food frequency questionnaire developed by Block et al (27) was used in its entirety (Appendix II). The portion sizes, however, were limited to the standard portion of medium. Additionally, a short section was added to determine the health, overall diet and exercise patterns of the pregnant women. This primarily was added to ascertain any changes in appetite due to nausea sometimes associated with early pregnancy.

Data Collection Procedures

Once a contact was made and appointment scheduled, the subject was assigned a number. The subject subsequently was mailed the semi-qualitative food frequency questionnaire which was to be filled out based on the year prior to becoming pregnant, a consent form and letter describing the study with a reminder to not eat or drink at least four hours prior to the appointment.

Each subject was phoned two days prior to her appointment as a reminder and to answer any questions she might have. When the subject arrived for the appointment, she brought the signed consent form and the completed food frequency questionnaire based on the previous year.

Upon arrival, demographic information such as age, parity, and pre-pregnancy weight was obtained by self-report. The subjects fasted at least four hours prior to the appointment, to allow for other procedures to be done before the underwater weighing. In addition, the subject did not engage in any formal exercise for 24 hours prior to the appointment.

A light snack was provided while the subject completed another self-administered semiquantitative food frequency questionnaire, this time based on the dietary pattern during the previous month. Once the questionnaire was completed, the subject changed into a swimming suit in a dressing room near the laboratory. The subject's height and weight, to the nearest one-quarter inch and one-quarter pound, respectively, then were taken in duplicate using standard procedures and equipment (42). The scale used was a Health-o-Meter, Physician Balance Beam Scale, Series 400 (Continental Scale Corporation, Bridgeview, IL).

Body density was measured by standard hydrostatic weighing technique (43). This included a submersion tank fitted with a submerged electronic "scale" placed on force cell transducers coupled to an integrated amplifier (Precision Biomedical Systems, Inc., University Park, PA). The electronic output fed into a chart recorder which recorded a continuous plot of the subject's underwater weight. Body mass was determined from the heaviest trial of no less than three. The subjects were fitted with a weight belt, at least two kilograms, to help keep them submerged upon exhalation. The subject bent forward while she fully exhaled, and held the position steady as long as she could. Body density was determined by the equation developed by Buskirk (44) using a computer program. The percentage of body fat during pregnancy was calculated through the use of an equation developed by van Raaij et al (15) (see Figure 1).

Lung residual volume was determined by the oxygen dilution technique (45) (Nitralyzer, Nitrogen Gas Meter, Model 505, MedScience, St. Louis, MO) immediately prior to underwater weighing. The subject assumed the same position that was required in the underwater tank. The entire process took approximately one hour. The subject received a copy of a current book on infant nutrition and ten dollars for participating in the study.

Data Management

All data were stored in a file locked in the Principal Investigator's office. The list of names is confidential, for possible use in a follow up

$$W_{FM} = \frac{W_B}{100} \times \frac{\left(\frac{100}{D_B} - \frac{100}{D_{FFM}}\right)}{\left(\frac{1}{D_{FM}} - \frac{1}{D_{FFM}}\right)}$$

W_{FM} = Weight of fat mass

W_B = Weight of body in kilograms

D_B = Density of body (from underwater weighing)

D_{FFM} = Density of fat-free mass (corrected for gestational age)

D_{FM} = Density of fat mass (constant 0.9)

Figure 1: General equation for estimating body fat mass from body density and body weight.

Source: van Raaij JMA, Peek MEM, Vermaat-Miedema SH, Schonk CM, Hautvast JGAJ. New equations for estimating body fat mass in pregnancy from body density or total body water. *Am J Clin Nutr.* 1988;48:24-29.

study. The food frequency questionnaire data were entered into the National Cancer Institute's computer analysis program. The macronutrient values were extracted from this report and entered into a computer file using the Quattro Pro spreadsheet program (47). As the data were entered, they simultaneously were double checked for accuracy. This consisted of typing in a page of data, followed by subsequent visual double-checking of the whole page.

A random sample of 25% of the total number of subjects completed a second food frequency questionnaire based on the prior month as a test for reliability. These were sent home with the subjects with instructions to complete the questionnaire within a week and send it back in using a pre-addressed and stamped envelope. A follow-up letter and another copy of the questionnaire were sent if the subject did not respond in two weeks.

Statistics

Data analysis used SPSS-PC$^+$ on an IBM PS/2 computer (48). Requirements for parametric statistics were checked by examining variables for a normal distribution and equal variances.

Frequency distributions, means and standard deviations were generated for all data. T-tests were used to assess the effect of parity on the pregnancy body fat percentage. Paired t-tests were run to evaluate the differences between dietary intakes reported on the year and month food frequency questionnaires. A Chi-square test was used to evaluate the relation between dietary fat and supplement use in order to establish concurrent validity. Pearson's Product-Moment Correlation Coefficients were determined to assess the association of pregnancy body fat percentage with pre-pregnancy body mass index, month percent dietary fat, and year percent dietary fat, respectively.

In order to assess the degree to which the dietary factors were associated with pregnancy body fat percentage, a stepwise multiple regression analysis was performed. The dependent variable was pregnancy body fat percentage and the independent variables were month percent fat, month kilocalories, pre-pregnancy body mass index, age, year percent fat, year kilocalories, and parity.

A backward stepwise multiple regression analysis was performed to evaluate the extent to which the total diet, as well as other pregnancy-related factors were associated with body composition during pregnancy. In a stepwise regression, the variable that explains the greatest amount of variance in the dependent variables will enter the equation first, the second variable that explains the second largest amount of the variance will enter next, and so on. A backward elimination is a stepwise regression that eliminates predictor variables one by one from the regression equation. Residuals were examined to determine the normality of the scatterplot, prior to the interpretation of the data.

All analyses were two-tailed, unless otherwise noted. Data were evaluated for significance at the $p < 0.05$ level, although lower significance values are included in the results.

CHAPTER IV

RESULTS

Forty pregnant women were recruited and assigned numbers in this study. One subject was unable to complete data collection; therefore, 39 subjects reported for this research project. One additional subject was dropped from the analysis. This subject was black and was not included based on the differences between whites and blacks in terms of bone mineral mass and lean body mass (49). Different body composition equations are used for black women, and a large enough subsample was not available. Therefore, these results include data from 38 white women or 97% of the total. Incomplete data do exist for a few participants and will be acknowledged in each section it affects.

The sample size originally estimated indicated that a minimum of 32 subjects was needed to provide power sufficient to conduct the study (41). Thus, to compensate for potential missing data, 40 subjects were recruited.

Characteristics of the Subjects

Table 1 lists the characteristics of the subject population. The range of ages for this population was 18 to 41 years, with a mean age of 28.6±6 years. Of the 38 women, 21 (55.3%) were primiparous, 11 had one child, 5 had two children, and 1 subject had three children. The number of subjects in each trimester were as follows: trimester one had 7 subjects, trimester two had 10 subjects, and trimester three had 21

Table 1: Mean characteristics of the study population[a].

Variable	Description
Age (years)	28.6±6
Parity	
primiparous (%)	55.3
multiparous (%)	44.7
Trimester	
One (number of subjects)	7
Two (number of subjects)	10
Three (number of subjects)	21
Gestational Age (weeks)	25±9
Height (inches)	64.2±3.4
Pregnancy Weight (pounds)	153.5±30.6
Pre-Pregnancy Body Mass Index	26.4±6

a N = 38

subjects. The mean gestational age was 25±9 weeks with a range of 6 to 38 weeks.

The mean height of the subjects was 64.2±3.4 inches with a range of 52.3 to 70.3 inches. The weight of the subjects taken during the study ranged from 100 to 230.3 pounds with a mean of 153.5±30.6 pounds. The pre-pregnancy body mass index was calculated from self-reported pre-pregnancy weight. This ranged from 17.5 to 49.5, with a mean of 26.4±6. When categorized by the Institute of Medicine's Guidelines (4), there were 3 subjects falling into the low pre-pregnancy BMI category, 20 in the moderate BMI category, and 15 subjects in the high BMI category.

The month food frequency questionnaire had a short section added to assess the subjects' perceptions of overall health. Over 63% of the subjects indicated their diets were fairly typical over the previous week. Only three subjects indicated their current health was fair, whereas, the remaining 35 subjects reported good to excellent health.

When asked of their current employment status, 68.4% responded they were working. In a comparison of current physical activity with pre-pregnancy activity, 62% stated they were less active. Fifty-eight percent indicated their physical activity in the previous month was less than their perceived activity of non-pregnant women the same age. Lastly, 76.3% of the women took vitamin and mineral supplements within the previous month, whereas, 13.2% did not take any supplements, and 10.5% took them irregularly.

Dietary Intake Data

As previously mentioned, the subjects' dietary intake was measured by a self-administered, semiquantitative food frequency questionnaire from the National Cancer Institute. The results from the computer analysis of the questionnaires are reported in Table 2. The nutrient intake is reported in terms of macronutrient composition only.

Year Food Frequency Questionnaire

Three women did not return their year food frequency questionnaires. All results using the year food frequency questionnaires are based therefore on an N of 35. The mean kilocalorie intake for the year prior to becoming pregnant was reported as 1986±728. The range of calorie intake, however, varied from 760.7 to 3812.4 kilocalories. The ranges for the percent composition of macronutrients were as follows: 22.9 to 55.6% fat, 29.3 to 63.0% carbohydrate, and 10.6 to 21.5% protein. The means for the percent composition of macronutrients were 37.3±9% fat, 45.1±9% carbohydrate, and 16.3±3% protein.

Month Food Frequency Questionnaire

The data for the previous month during pregnancy reported a mean caloric intake of 2209±686. This is a 223 kilocalorie increase over the reported yearly intake. The kilocalories, however, ranged from 760.7 to 3483.3. The percent composition of macronutrients for the month ranged from 20.2 to 59% fat, 21.9 to 61.7% carbohydrate, and 10.3 to

Table 2. Dietary intake of subjects from the month and year food frequencies[a].

Nutrient Intake	Mean±S.D.
Month Food Frequency Results	
Kilocalories	2209±686
Fat (% of Kcal)	36.8±8
Carbohydrate (% of Kcal)	46.1±8
Protein (% of Kcal)	16.6±2
Year Food Frequency Results	
Kilocalories	1986±728
Fat (% of Kcal)	37.3±9
Carbohydrate (% of Kcal)	45.1±9
Protein (% of Kcal)	16.3±3

a N = 38 for month food frequency and 35 for year food frequency

22.3% protein. The means for the percent composition of calories were 36.8±8% fat, 46.1±8% carbohydrate, and 16.6±2% protein.

Assessment of Concurrent Validity

The percent dietary fat for the month was divided at the median into two groups to enable a crosstabulation with supplement usage. In order to assess concurrent validity, the researchers hypothesized that women with lower fat diets would be more likely to be regular users of supplements than women with higher fat diets. The "low fat" group had dietary fat percentages less than 36.3 and the "high fat" group had percentages greater than or equal to 36.3. The supplement usage was grouped as well; those who regularly took supplements versus those who did not or only periodically took supplements. The Chi-square of the cross-tabulation was 4.5, following a Yates correction for small cell size. It was found that the subjects who regularly used supplements were significantly more likely to be in the lower dietary fat group than those who did not use them, at the $p < 0.05$ level.

To further establish concurrent validity, the mean difference between the energy intakes for the year prior to pregnancy and the month during pregnancy was compared to the RDA. The mean difference was 223 kcal verses the 300 kcal recommended for pregnancy. Therefore, data appeared to exhibit concurrent validity.

Assessment of Reliability

To test the reliability of the questionnaire in establishing nutrient intake in this population, a random sample of 10 subjects was assigned to complete a second food frequency based on the previous month. Nine of the ten women assigned returned their food frequency questionnaires. When the two monthly food frequencies were compared for each woman, the percent deviation was calculated for each macronutrient. The results are presented in Table 3. Overall, the mean percent deviation ranged from 9.4 for kilocalories to 3.7 for percent carbohydrate. The percent deviation for fat was 5.0. Thus, subjects exhibited consistency in their responses to questions about their dietary intake.

Differences Between Month and Year Intakes

Table 4 lists the significant differences between reported intakes from year to month food frequencies. Paired t-tests resulted in no significant differences between year and month, when the data were analyzed by percent kilocalories from the macronutrients. The absolute grams of each macronutrient and kilocalories, however, did significantly increase from the year to the month questionnaire. The increase in kilocalories was distributed evenly among the macronutrients and was influenced particularly by an increase in dairy products, as noted by a casual observation. These particular food products provided carbohydrate, protein, fat and calories to their diets.

Table 3: Reliability of nutrient intakes for the random sample that completed two month food frequencies[a].

Subject	Kcal	Fat	Carbohydrate	Protein
4	8.2	3.7	0.2	5.8
8	6.4	7.9	4.5	2.6
11	13.6	5.9	6.4	3.7
23	16.5	5.9	5.7	15.4
25	5.5	4.6	3.4	6.7
29	4.8	2.1	1.5	0.9
30	25.2	11.1	10.3	7.3
32	0.8	1.5	0.5	2.9
37	4.0	2.5	1.2	1.7
Mean	9.4	5.0	3.7	5.2

a Percent deviation for reliability was calculated as follows and rounded to the nearest tenth:

$$\frac{(\text{Value Month FFQ - Value Reliability Month FFQ})}{(\text{Value Month FFQ + Value Reliability Month FFQ})} \times 100$$

FFQ = Food Frequency

Table 4: Significant differences associated between the nutrient intakes reported on the year and month food frequencies using paired t-tests[a].

Variable	Mean±SD	t-Value	Significance[b]
Month Kcal	2260±687	3.42	0.01
Year Kcal	1986±728		
Month Fat Grams	94.6±42	2.13	0.05
Year Fat Grams	84.8±43		
Month CHO Grams	255.8±73	4.18	0.0001
Year CHO Grams	219.5±80		
Month Protein Grams	93.3±33	3.27	0.05
Year Protein Grams	80.0±29		
Month Percent Fat	36.8±8	(-) 0.83	NS
Year Percent Fat	37.3±9		
Month Percent CHO	46.1±8	1.66	NS
Year Percent CHO	45.1±9		
Month Percent Protein	16.6±2	0.38	NS
Year Percent Protein	16.3±3		

a N = 35

b t-test using two-tailed significance

Body Composition Analysis

The subjects were hydrostatically weighed to determine their lean body mass. Using equations specific for pregnancy, their body fat was determined from their underwater weight (15). Of the 38 subjects only 37 were underwater weighed, as one subject was unable to exhale underwater sufficiently. The mean body fat percentage derived from underwater weighing was 30.2±6.5%, with a range of 18.2 to 46.3%.

To test the effect of parity on pregnancy body fat percentage, the subjects were grouped into two categories, primiparous and multiparous. Using a t-test, it was found that the respective mean body fat percentages of 30.2±6 and 30.1±7 were not significantly different.

A Pearson's Product-Moment Correlation of 0.71 ($p < 0.001$) was found between pre-pregnancy BMI and calculated pregnancy body fat percentage. When the year dietary fat was tested against the pre-pregnancy BMI, no significant correlation was found. There was, however, a positive relationship at 0.40. When pregnancy body fat percentage was correlated with both month and year dietary fat percentages, correlations of 0.39 and 0.31 were found, respectively. Although these were not significant, they indicate a positive relationship. The correlation between month and year dietary fat percentage was 0.81 ($p < 0.001$), suggesting that the percentage of fat in the diet is relatively consistent pre-pregnancy and during pregnancy.

Table 5 lists the means of selected variables reported by tertiles of pregnancy body fat percentage. The tertiles of pregnancy body fat percentage were as follows: tertile 1 was 24.3±3.8%, tertile 2 was 29.8±1.5%, and tertile 3 was 36.9±5.4%. There is an increase of

Table 5: Means of selected variables reported by tertiles of pregnancy body fat percentage.

Variable	N	Mean±SD	Tertile 1	Tertile 2	Tertile 3
Pregnancy Body Fat %	37	30.2±6.5	24.3±3.8	29.8±1.5	36.9±5.4
Month Kcal	37	2193±688	2093±830	2365±664	2129±554
Month % Fat	37	36.7±8.1	33.1±7.3	37.3±8.6	40.1±7.6
Month % CHO	37	46.2±8.3	49.3±6.7	46.0±8.5	43.1±9.1
Month % Protein	37	16.6±2.4	16.9±2.0	16.5±2.5	16.4±2.9
Year Kcal	34	1951±709	1947±792	2109±771	1767±531
Year % Fat	34	37.3±8.6	34.2±6.5	38.1±9.9	40.0±8.9
Year % CHO	34	45.2±8.6	47.7±5.7	44.7±11.1	42.8±8.2
Year % Protein	34	16.2±2.5	17.0±1.9	16.1±3.1	15.5±2.5

pregnancy body fat percentage with each tertile, as well as a corresponding increase in month dietary fat percentage.

Table 6 represents the summaries of mean pregnancy body fat percentage, month dietary fat percentage, and month kilocalories, by trimesters rather than tertiles of body fat percentage. This portrays a different picture of body fat percentage with corresponding dietary intakes. Thus, data suggest there is a relationship between diet and body fat during pregnancy. It may be influenced, however, by other variables as well.

A stepwise multiple regression was executed to assess the relationships of the variables to pregnancy body fat percentage. The aim of this analysis was to identify those variables that might help explain the dependent variable of pregnancy body fat percentage. The first multiple stepwise regression considered only the dietary factors. Out of month and year kilocalories, month and year percent fat, month and year percent carbohydrate, and month and year percent protein, the only variable associated with pregnancy body fat percentage was month percent fat. This accounted for 15% of the variation in body fat percentage, with an F of 5.35 and a significance of $p < 0.05$.

Table 7 shows the multiple stepwise regression analysis based on the variables parity, year kilocalorie intake, age, pre-pregnancy body mass index, year percent fat intake, month kilocalorie intake, and month percent fat intake against the dependent variable of pregnancy body fat percentage. For each of the steps, the variable that explains the least amount of the variance is removed from the equation. The residuals were examined before data interpretations were initiated. The scatter

Table 6: Summaries of mean pregnancy body fat percentage, month dietary fat percentage, and month caloric intake by trimester of pregnancy.

Variable	Trimester 1	Trimester 2	Trimester 3
Number	7	10	21
Pregnancy Body Fat Percentage	30.4±8.7	26.6±6.4	31.9±5.1[a]
Month Fat Percent	34.0±9.2	38.0±7.0	37.1±8.3
Month Kilocalories	1846±440	2481±902	2201±602

a N = 20 for trimester 3, pregnancy body fat percentage

Table 7: Multiple stepwise regression analysis of factors upon pregnancy body fat percentage.

Independent Variables	Dependent Variable	F	R^2	P
Step 1 Variables: Parity Year Kcal Age Pre-Preg. BMI Year % Fat Month Kcal Month % Fat	Pregnancy Body Fat Percentage	5.0	0.58	0.001
Step 2 Variables: Parity Year Kcal Age Pre-Preg. BMI Year % Fat Month % Fat	Pregnancy Body Fat Percentage	6.0	0.58	0.0005
Step 3 Variables: Parity Year Kcal Age Pre-Preg. BMI Month % Fat	Pregnancy Body Fat Percentage	7.2	0.57	0.0002
Step 4 Variables: Parity Age Pre-Preg. BMI Month % Fat	Pregnancy Body Fat Percentage	8.7	0.55	0.0001
Step 5 Variables: Parity Pre-Preg. BMI Month % Fat	Pregnancy Body Fat Percentage	10.9	0.53	0.0001
Step 6 Variables: Parity Pre-Preg. BMI	Pregnancy Body Fat Percentage	15.2	0.50	0.00001

plots were found to be free from abnormalities, thus allowing interpretation of the results.

Month dietary fat percentage was the last dietary factor to be removed from the equation in step five. The effects of parity, pre-pregnancy body mass index and month dietary fat percentage accounted for 53% of the variation in pregnancy body fat percentage, significant at the $p < 0.0001$ level. The variables of parity and pre-pregnancy body mass index were the last variables to remain in the equation with a F of 15.2, R^2 of 0.5 and a significance of $p < 0.00001$.

Thus, when only dietary variables were examined, month dietary fat percentage was significantly associated with pregnancy body fat percentage. When diet and other variables associated with pregnancy and body fat were examined, month dietary fat percentage was still significantly associated with pregnancy body fat percentage, even though pre-pregnancy BMI and parity accounted for a large portion of the variance.

CHAPTER V

DISCUSSION

A majority of the research conducted during pregnancy has concentrated on the effects of inadequacies in the diet. The study of body composition changes in accordance with the diet of populations has been gaining increasing exposure. This study, therefore, was meant to be an initial step in describing the relationship between consumption of macronutrients during pregnancy and body composition of the mother.

Characteristics of Subjects

This study was of a population of 38 pregnant white women, ranging from 6 to 38 weeks gestation. While the second and third trimesters contain more subjects than the first, these are the pregnancy stages that produce the most change in dietary intake and body composition (4,50).

The mean pre-pregnancy body mass index of 26.4±6.0 indicated that these women, as a whole, were not underweight prior to their pregnancies. The Institutes of Medicine's (4) categorization of pre-pregnancy BMI would suggest that this mean BMI falls just into the high BMI category of > 26.0. The subjects' BMI were calculated based on self-reported pre-pregnancy weight, which in itself could be under or overestimated.

The mean age of 28.6±6 years indicates that this population may be representative of the trend of delayed childbirth in the North American society. A split of 55% primaparous and 45% multiparous assures that this is not a parity-biased sample. The concurrent validity results indicate that the assumptions about this population were correct. There was a caloric increase of 223 kcal from the year dietary intake to the month intakes during pregnancy, and there was a higher supplement usage in the lower dietary fat subjects. Although this is a small sample of volunteers, it does not appear that systematic biases exist within this sample.

Dietary Intake

The semiquantitative food frequency questionnaire used in this study is a reliable measure of the subjects' dietary intake. The mean percent deviations from the random sample that completed two monthly food frequency questionnaires all were below 10% for kilocalories and percent macronutrients.

This study focused on percent macronutrients and kilocalories. Several studies indicated that this may be a more valid measure of mean dietary intake, because food frequency questionnaires tend to underestimate other nutrients (30,33,34).

Food Frequency Questionnaire Based on the Previous Year. The data from the food frequency questionnaire based on the year prior to pregnancy is very similar in percent macronutrients, when compared to Block and Subar's analysis of the 1987 National Health Interview Survey (51). The percent of kilocalories from fat was, however, slightly higher in this study's population when compared to their adjusted findings; 37.2±8.4% compared to 36.5±0.1%, respectively. The adjusted kilocalorie intake of the women in the National survey was 327 kilocalories lower than what was reported by this population on the year food frequency questionnaire. In a study by Thompson et al (23) the percent kilocalories from fat for women aged 19 to 50 years was 36.8%, which is similar to what was found in this population.

A literature review did not find any studies comparing pre-pregnancy intake with pregnancy intake. However, the "event" of pregnancy may be enough of a life-altering occasion that the women in this study would not have any problem discriminating between pre-pregnancy and pregnancy dietary intakes. Food frequency questionnaires have been used separately with pregnant, as well as non-pregnant women. Therefore, using both in the same study design should yield plausible data.

Food Frequency Questionnaire Based on the Last Month. The food frequency questionnaire based on the previous month during pregnancy had a significant increase of 223 kilocalories over what was reported for the year. This is a suggestion that dietary intake did increase to compensate for pregnancy, coinciding with the RDA established recommendation to increase kilocalories by 300. Other dietary changes that would be expected in this population happened as well. Through casual observation it was noted that the caffeine and alcohol consumption decreased, which is consistent with what is presented in the literature (39,40).

The correlation between the month and year dietary fat percents was 0.81 ($p < 0.001$). This indicates that the percentage of dietary fat did not change from intakes in pre-pregnancy to pregnancy. In addition the paired t-tests also concluded that there was no significant change from the year to month dietary intakes for fat. Even though kilocalories did increase significantly, the percent composition of macronutrients did not change from year to month. The increase in absolute grams of each macronutrient did increase significantly to warrant the increase in kilocalories.

There was a wide range of energy consumption. However, neither the low nor the high values were too extreme to be dropped from the analysis. In comparison with the Suitor et al (5) study, the mean caloric intake was lower for the pregnant women in this study than what they reported. Using a food frequency questionnaire, Suitor et al found mean energy intakes of 2518±921 kcal, when those consuming greater than 4,500 kcal were left out of analysis. One of their conclusions suggests that 20% of their population probably overestimated consumption. In addition, their study tested low-income women. The current study did not objectively ask the income of each of the subjects. However, the observation was made that these women were mostly middle income, as a large percentage of the women were practicing professionals or students at the university.

When the mean dietary intakes were evaluated by trimester, the 1846±440 kcal intake in the first trimester was very similar to the 1986±728 kcal intake before pregnancy. The second and third trimesters produced kilocalories of 2481±902 and 2201±602. The percent dietary fat for the second trimester was higher at 38±7% versus the third trimester at 37.1±8%.

A study by Celleir and Hankin (52) found similar results for the second and third trimesters. The second trimester consisted of a higher energy and fat consumption than the third. The reason for this was not stated. However, this may be explained by Hytten's findings (50). He states that, "specific energy requirements are greatest during the middle two quarters of pregnancy....the overall effect is to spread the additions to total calorie needs over about three-quarters of pregnancy, and there is not increase of demand during the final weeks." This may suggest that the women were consuming additional calories to meet the growth demands of their bodies. Since this study divided the subjects into trimesters, and not quarters, it allows only for speculation.

Body Composition and Diet

Body fat was estimated from equations using lean body mass derived from underwater weighing. The equations specific for pregnancy, based on gestational age, were developed by van Raaij et al (15). The general equation is shown in Figure 1.

Pre-pregnancy body mass index was significantly correlated with pregnancy body fat percentage at 0.71 ($p < 0.001$). This is consistent with the assumption that the body composition existing before pregnancy would have an impact on the body composition during pregnancy.

When the body fat was divided into tertiles, mean body fat and mean month dietary percent fat did increase from one tertile to the next. This is supported in the review by Rolls and Shide (17) who found as body fat increased, percent dietary fat also increased. However, when the body fat percentage was divided according to trimester, the second trimester was the leanest of the three. This is in comparison with the dietary data that found the second trimester having 38% of the kilocalories from fat, which was more than the other two trimesters. This seems in direct conflict with what one would expect from the data. However, this might be explained by the small sample size, the unequal numbers in each trimester and the particular subjects in the second trimester.

The correlations between dietary factors and pregnancy body fat percentage, although not significant in this sample, were positively associated. The correlation of 0.39 between month dietary fat percent and body fat is very similar to the 0.37 ($p < 0.001$) correlation found in a study by Miller et al (21). While their subjects were not pregnant, the correlation was significant in their female subjects. It is suggested that due to such a small sample size, the 0.39 correlation was not significant in this particular sample of pregnant women.

Tucker and Kano (22) also found dietary fat to be significantly correlated with body fat percentage in 205 females. While their subjects were not pregnant, they did use the same food frequency instrument.

Several retrospective studies have found parity to have a strong effect on body composition (4,8,10,11). When parity was tested against body fat percentage in this study, no difference in mean body fat was found between prima and multiparous subjects. The means for body fat percentage were virtually identical. However parity and pre-pregnancy BMI were found to be highly predictive of pregnancy body fat percentage, upon analysis of multiple stepwise regression. This may indicate more prospective studies are needed to assess this relationship.

The multiple stepwise regressions found that of all the dietary factors, month percent fat was the only one to contribute significantly to pregnancy body fat percentage. When other factors were added such as age, parity and pre-pregnancy BMI, month dietary fat percentage was the last dietary component to remain in the equation. However, the last two remaining variables in the equation were parity and pre-pregnancy BMI. These were the two variables that had the most impact on pregnancy body fat percentage and together explained 50% of the variation in the body fat percentage.

Implications

While this study may not conclusively prove there is a significant relationship between dietary fat and the amount of fat stored during pregnancy, a relationship was shown to exist. The studies by Tucker and Kano (22) and Miller et al (21) did find a significant relationship with dietary fat and body fat in the non-pregnant state. Tucker and Kano used the same food frequency questionnaire that was used in this study. However, the current study's limitations were the small sample size, unequal numbers within trimesters, and lack of a prospective component. If this study were to be repeated on a larger sample of pregnant women and include a prospective component, more relationships might be identified.

Underwater weighing does not lend itself to be used in large-scaled studies on pregnant women due to high respondent burden. If another method, such as bioelectrical impedance, was validated in this population, it would greatly increase the portability and access to subjects. The feasibility of a longitudinal study would greatly be increased by choosing a low respondent burden method of assessing body composition.

Recommendations

Other areas that could be explored in a study such as this are the amount of prenatal care the subject received, nutrition education received and from whom, socioeconomic status of the subjects, and a more expanded dietary assessment to include all sources of fat in the diet. For example, 24 hour recalls, or food records could be used to supplement the information obtained from the food frequency questionnaire.

Increasing the number of subjects would allow relationships to be more clearly understood. The impact of dietary fat on the body composition changes during pregnancy then could be better assessed. This would allow the alteration of nutrition education for pregnant women to include such topics as meeting caloric needs through a lower fat diet.

Summary

Oscai et al (48) found that an increase in dietary fat did increase body fat deposition in rats. However, human confounders such as age and heredity can easily be controlled in animal experiments. When epidemiological studies of human populations are undertaken, confounders must be controlled.

This study's limits are grounded in the fact that 38 pregnant women of differing gestational ages is a very small population to analyze.

However, with data from body fat and dietary fat on non-pregnant populations suggesting that there is a correlation between the two, this study may provide a first step in looking at pregnancy (21,22). The National Institute of Medicine recognizes this and calls for more research in this area (4).

While the sample size is small, there was a significant stepwise multiple regression analysis that identified previous month's dietary fat percent as having an effect on pregnancy body fat percentage. The division into tertiles of pregnancy body fat percentage also illustrated that with increasing body fat percentage, there was a mean increase in dietary fat percentage. This may indicate that by adjusting the composition of the calories in the diet from fat, less fat deposition will occur. Less fat deposition may mean less residual weight, which might decrease the risks of chronic diseases later in life. These results indicate that further studies need to be undertaken in this area and that the mechanism for this phenomenon must be discovered.

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APPENDICES

APPENDIX I

DEFINITION OF TERMS

Waist to Hip Ratio: The waist to hip ratio (W/H) is calculated by dividing the waist circumference by the hip circumference (cm/cm). Waist circumference is obtained by measuring at the narrowest point between the lower rib margin and the iliac crest. The hip circumference is measured at the widest point between the hip and buttock. The measures are taken while the subject stands, using a inelastic tape measure read to the nearest millimeter (42). This value is commonly used as an indicator of the degree of masculine distribution of adipose tissue. The higher the W/H, the greater the risk of some chronic diseases.

Body Mass Index: Body mass index (BMI) is calculated by dividing a subject's weight, in kilograms, by their stature squared, in meters (42). (BMI = kg/m^2)

Underwater Weighing: Underwater weighing is an assessment of body composition by the measurement of whole-body density (12).

Semiquantitative Food Frequency Questionnaire: A semiquantitative food frequency questionnaire has a standard portion size stated on the questionnaire or assumed by the investigator for each food listed, and the respondent is asked to relate frequency of intake in terms of the standard portion sizes (33).

APPENDIX II

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 somewhat less than usual over the past week, but it does not seem unusual.
   c. I have been eating quite a bit less than usual and I am not concerned.
   d. I have been quite a bit less than usual and I am concerned.

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. Other

   Please describe how this affected your diet?

4. Are your 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 deal
b. a moderate amount
c. a little
d. none

6. How would you compare your level of physical activity during the last MONTH with other persons your age?

a. more active
b. less active
c. about the same

7. How would you compare your current level of physical activity during the last MONTH with your level before you became pregnant?

a. more active
b. less active
c. about the same

8. Read the following list of activities and circle the letter which best describes how often you perform each one NOW compared to BEFORE your pregnancy?

activity		MORE	SAME	LESS	NOT APPLICABLE
a.	walking	3	2	1	0
b.	sleeping	3	2	1	0
c.	housework	3	2	1	0
d.	reading	3	2	1	0
e.	watching tv	3	2	1	0
f.	exercising	3	2	1	0
g.	relaxing	3	2	1	0
h.	other________	3	2	1	0
i.	other________	3	2	1	0

9. Have you performed any physical activity in the last 2 days?

a. No
b. Yes

If yes, what?____

If yes, when?____

Section B. Food Frequency and Diet History

10. During the past year, have you taken any vitamins or minerals?

_____(N) No
_____(Y) Yes, fairly regularly
_____(YN) Yes, but not regularly

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	______	Selenium	______
Zinc	______	Iron	______
Beta-carotene	______	Cod liver oil	______
Other	______		

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

11. This section is about your usual eating habits. Thinking back over the YEAR before your became pregnant, 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 year before you became pregnant. 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 YEAR before you became pregnant, look at the serving size. A medium serving is listed and you should adjust the number of servings if you typically ate or drank small or large 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 you 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, 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. And please be careful 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 last MONTH.

Please look at the example below. This person:

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

EXAMPLE:

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

FRUITS & JUICES	Medium Serving	Day	How Often? 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	8 oz. glass				
Other fruit juices, fortified fruit drinks	6 oz. glass				
Any other fruit, including berries, fruit cocktail	1/2 cup				

VEGETABLES	Medium Serving	Day	How Often? 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, limas	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	Day	How Often? 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				

LUNCH ITEMS	Medium Serving	Day	How Often? 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	Day	How Often? 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	Day	How Often? 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	Day	How Often? 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	Day	How Often? 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				

Have you gained or lost more than five pounds in the past year before you became pregnant? (You may check more than one answer).

1 ____ No 2 ____ 5-15 lbs. 3 ____ Lost 16-25 lbs. 4 ____ Lost more than 25 lbs.
5 ____ Gained 5-15 lbs. 6 ____ Gained 16-25 lbs. 7 ____ Gained more than 25 lbs.

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

Think about your diet over the year before you became pregnant and the responses you have just 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 particularly 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 at the bottom of the page.

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

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

How often did you use fat or oil in cooking?
For example, in frying eggs, meat or vegetables? ________ times per ________
day, week, month

What did you usually cook with? 1 ____ Don't know or don't cook 2 ____ Soft margarine
3 ____ Stick margarine 4 ____ Butter 5 ____ Oil 6 ____ Lard, fatback, bacon fat
7 ____ Pam or no oil

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

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

If you ate cold cereal, what kind did you eat most often? ________________

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

________________ per ________________
vegetables day, week

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

________________ per ________________
fruits day, week

VITA

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