Maternal Anthropometric Measures and Nutrient Intake During the Second Trimester of Pregnancy of Normal Weight and Overweight Gravidas

by

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(ABSTRACT)

Weight, skinfold, and circumference measurements were obtained from 29 normal weight and 17 overweight ($\geq$ 110% of desirable weight for height) healthy pregnant women every four weeks during their second trimester of pregnancy. The mean weight gain and food intake values were not significantly different for both groups. Measurements increased at a greater rate for the normal weight gravidas than for the overweight gravidas in almost every case. For both groups, increases in fat stores were greater in the central sites than in the peripheral sites. No clear relationship betwen age, prepregnant weight, and weight gain during the second trimester with the birthweight of the baby was found. The infant birthweights of both groups were at an optimal level ($>$ 2500 grams) except for one (born to the mother 151% of her desirable weight for height). The similarity in results for the two groups is greatly due to there not being a large enough difference in prepregnant weights between the two groups. Nevertheless, the results do lend support to a 20 to 30 pound weight gain for an optimal outcome of pregnancy for healthy pregnant women with a wide range of prepregnancy weights. Those women 150% or more of their desirable weight for height may need to gain on the lower end of the spectrum due to their excess endogenous reserves and to possible harm to the fetus with large gains.

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INTRODUCTION

There are many complications associated with obesity during pregnancy, including increased perinatal mortality rates. In promoting the optimal outcome of pregnancy, researchers can use birthweight as an indicator for success. Prepregnant weight and gestational gain are two of the strongest influences on birthweight; therefore, an ideal combination needs to be determined. Most of the research to date has been concerned with the pregnancies of normal weight women. These studies indicate that women do lay down fat primarily during midgestation (10-30 weeks) in the central sites of the body. Those fat stores do decrease from the 38th week until one week postpartum; the fat being an energy source for the fetus. The purpose of this investigation is to examine the pattern of weight gain in both normal weight and overweight women during the second trimester of gestation, using skinfold and circumference measurements. Based on the results, a statement can then be made regarding the appropriateness of currently recommended weight gain patterns for overweight gravidas.

REVIEW OF LITERATURE

Influences on Birthweight

Obesity has become an increasingly prevalent problem as it affects between 25 and 45 percent of the U.S. adult population (Udall et al., 1978). This is of concern in pregnancy because serious complications are more likely to develop in obese women such as hypertension, diabetes, aspiration during anesthesia, wound complications, pyelonephritis, and thromboembolism (Pritchard and McDonald, 1976, Tracy and Miller, 1969). At the same time, in the massively obese woman (150% of standard weight for height), there is an increased incidence of inadequate weight gain (12 lbs.) in pregnancy (Edwards et al., 1978). Harrison et al. (1980) found that only 4% of nonobese women had inadequate gain, while 15% of moderately obese and 19% of massively obese had inadequate gains. In fact, in 3 of 4 individuals in the massively obese group with inadequate gains, there were actually net weight losses during the pregnancies. Furthermore, there is a hazard for the fetus (Edwards et al., 1978, Calandra et al., 1981). Prolonged labor, difficulties in selection of an appropriate analgesic, and an increased need for the induction of labor may be the reason for the low APGAR scores seen in infants born to obese mothers (Calandra et al., 1980, Edwards et al., 1978). There is an increase in large infants (>4.5 kg or ~ 10 lbs.) to parallel increasing degrees of obesity and a decreasing incidence of low birth weight (LBW) infants (Luke, 1979, Harrison et al., 1980, Edwards et al., 1978, Calandra et al., 1981).

Moreover, Edwards et al. (1978) found that by the time the infants of obese women were 12 months of age, they were significantly more obese than controls. Even more serious, there was increased incidence of stillborns found among obese gravidas in the Vanderbilt Cooperative Study (Luke, 1979). An essential goal is to minimize these complications and optimize the outcome of pregnancy in obese women.

Previously, investigators have concentrated on the other end of the spectrum of maternal pregravid weight, the underweight gravida. They have noted a strong correlation between increasing gestational gain, pregravid weight, and birthweight. Birthweight is useful as an indicator for a successful outcome of pregnancy as it is directly related to neonatal morbidity and mortality (Luke, 1979, Phillips and Johnson, 1977). Researchers have now recognized that weight gain and pregravid weight are the two strongest influences on birthweight (after gestational age), but that the ideal combination needed to produce an infant of optimal weight has yet to be defined (Luke and Petrie, 1980). Some researchers have used multiple regression analysis techniques to attempt to explain the variability in birth weight attributable to maternal and environmental factors (Phillips and Johnson, 1977).

Because the few studies that have been done with obese gravidas have associated excessive growth of the fetus and the multitude of complications with the obese state, a regime of minimal gain or even net loss in the management of their pregnancies has been recommended (Luke and Petrie, 1980). Specifically, it was believed that limited weight gain would decrease the risk of cesarean section deliveries of large

birthweight infants and of toxemia. A 10 to 15 pound recommended weight gain was common in the 1950's and is still in practice today by some (Suter and Ott, 1984). Current trends have been toward liberalizing weight guidelines and viewing restriction as a form of relative starvation which can lead to ill effects in the newborn (Gormican et al., 1980). A maternal weight gain of 22 to 27 pounds (approximately 80,000 kcal) is recommended by the American College of Obstetrics and Gynecology since perinatal mortality rates are lowest with these gains (Suter and Ott, 1984). However this data is for women of normal pregravid weight and does not take variations in maternal nutritional reserves into account.

We are now recognizing the optimal weight gain may depend on prepregnancy weight and the quality of maternal nutritional reserves (Naeye, 1979). It is not known if obese or very thin women have the same optimal weight gain as do women with more normal proportions. Underweight women may need to gain more than 22 to 27 pounds. In contrast, overweight women and grossly overweight women might be advised to gain approximately 20 pounds and 15 to 16 pounds during pregnancy respectively (Naeye 1979). There are many factors such as maternal height, age, parity, race, and stresses added to pregnancy such as smoking and alcohol consumption habits, disease, socioeconomic status, etc. that may also influence optimal weight gain values and should be taken into consideration (Luke and Petrie, 1980; Naeye, 1979).

Pattern of Weight Gain for Normal Weight Gravidas

Generally, the rate of weight gain is sigmoid in shape when plotted. During the first trimester, there is minimal accumulation, almost all of it being in the maternal compartment. The slope is steepest, corresponding to a maximum rate of gain, at or before midgestation. The rate increases to about 0.36 kg/week during the 13-18th weeks. There is then an acceleration up to 0.45 kg/week by the 26-28th weeks. Finally, there is a reduction in rate to 0.36-0.41 kg/week until term, with weight gain related to products of conception predominating (Luke, 1979, Hytten and Leitch, 1971).

The estimated distribution of components of gain is shown in Table 1. The total accountable weight gain is less than the observed average gain; the difference is in maternal stored fat (Luke, 1979). Under optimal conditions, a woman is in positive energy balance throughout gestation and ends her pregnancy with a substantial increment in her fat reserve (Naismith, 1980). Skinfold measurements support the hypothesis that maternal fat is stored during gestation, particularly during midgestation in response to progesterone secreted by the feto-placental unit. The rate at which fat is stored diminishes to zero as term is approached. The hormone estriol, also produced by the feto-placental unit, that is believed to curtail fat deposition by antagonizing the action of progesterone and placental lactogen, secreted in increasing amounts during the third trimester, has been shown to stimulate the release of fatty acids from adipose tissue (Naismith, 1980, Taggert et

Table 1. Estimated distribution of components of gain.

Components	Amount (kg) gained per trimester: first	second	third
Fetus	negligible	1.0	3.4
Placenta	negligible	0.3	0.6
Amniotic fluid	negligible	0.4	1.0
(Fetal subtotal)		(1.7)	(5.0)
↑ uterine size	0.3	0.8	1.0
↑ breast size	0.1	0.3	0.5
↑ blood volume	0.3	1.3	1.5
↑ extracellular fluid	0	0	1.5
(maternal subtotal)	(0.7)	(2.4)	(4.5)
TOTAL GAIN ACCOUNTED FOR	0.7	4.1	9.5

Luke, 1979

al., 1967). However, in well nourished women, fat deposition invariably exceeds withdrawal (Naismith 1980).

The fat stored represents a potential energy source of great magnitude; $\sim$2 kg provides 18,000 kcal (Prentice et al., 1981). The fat may be deposited in anticipation of the requirements for fetal growth during the last trimester or for lactation.

Besides fat deposition and mobilization, there are other changes in maternal body composition that occur during pregnancy. The hormonal system of the woman is modified to also increase nitrogen retention, as demonstrated by nitrogen balance studies; to increase water retention, as evidenced by increased maternal blood volume and edema; and to provide adequate glucose and amino acids to the fetus (Taggert et al., 1967, Lechtig et al., 1975). These changes allow for appropriate nutrients to be available to the fetus, independently of modest alterations in the maternal diet. If the stores are depleted, factors such as present maternal nutrient intake, prepregnancy nutritional status (availability of maternal body reserves), and the efficiency of conversion of maternal tissue into fetal growth would be more important (Lechtig et al., 1975). If nutrients which must be provided by the maternal diet and reserves are low, fetal growth can be retarded. If they are in excess, there may be increased placental transfer of free fatty acids (Udall et al., 1978).

Pattern of Weight Gain for Obese Gravidas

Naeye (1979) used data from the Collaborative Perinatal Project of the National Institute of Neurological and Communicative Disorders and Stroke to study the relationship of weight gain to the outcome of pregnancy in 53,518 pregnancies. He wanted to determine if a 24 to 27 pound weight gain is optimal for all singleton pregnancies or if it requires modification for specific subgroups. Based on Hytten and Leitch's (1971) values of average weight gain, 8.5 lbs. at 20 weeks and 19 lbs. at 30 weeks, intermediate values were calculated to establish an optimal cumulative weight gain for each week of pregnancy. Naeye then computed the mother's weight gain as a percent of the optimal value. In addition, the mother's prepregnant weight for height was calculated as percent of mean desirable values published by the Metropolitan Life Insurance Co. (1959).

Naeye found that the most overweight mothers (prepregnancy weight over 135% of desirable values) had the lowest perinatal mortality rate when their weight gains were 24 to 54% of optimal values, as opposed to the thin and normally proportioned mothers having the lowest rate when prepregnancy weight gains were 80 to 120% of optimal values. In term pregnancies, the most favorable gain for very overweight mothers was 15 to 16 pounds. However, overweight mothers had higher perinatal mortality rates in most weight categories than those of normally proportioned mothers. Naeye found that maternal age, parity, race, family income, number of maternal visits for antenatal medical care, mothers' cigarette smoking, and prior unsuccessful pregnancy had no

significant effect on relative differences in perinatal mortality rates between maternal weight gain categories.

Naeye concluded that a mother's optimal weight gain in pregnancy does depend on her body size; optimal weight gain for overweight mothers being about half that for a very thin mother. The presumed reason is that overweight mothers have more adipose tissue and probably nonadipose tissue on which the fetus can draw. He does caution limiting caloric intake in overweight gravid women since the weight for height standard that he used does not distinguish overfat from large build. In addition, the quantity and balance of amino acids and other nutrients supplied from maternal reserves may not be as favorable to the fetus as those derived from dietary intake. Even large deposits of fat do not seem to ensure optimal outcome of pregnancy when weight gains are very low or mothers lose weight since overweight mothers in the lowest weight gain category had perinatal mortality rates twice those of overweight women with somewhat larger gains. The increased perinatal mortality rate may be due to maternal acetonuria. On the other hand, perinatal mortality rates increased when mothers gained more than 32 pounds. The baby seems to be more vulnerable to deficiencies and excesses than has often been assumed.

Edwards et al. (1978) found that with 208 massively obese patients (50% above standard weight for height, Metropolitan Life Insurance tables) there was a highly significant incidence of inadequate weight gain; 31.2% as opposed to 4.3% in the control. Yet the number of LBW infants was approximately half in obese compared to the controls. The

increased prepregnant weight seemed to lessen the impact of low prenatal weight gain on the birthweight of the infant. One could conclude that minimal gain or weight loss during pregnancy is of less concern in massively obese women than in nonobese counterparts. However the caloric cost of pregnancy is still 80,000 kilocalories, equivalent to the weight gain of 20 to 25 pounds. Weight loss or failure to gain weight implies catabolism of maternal tissue thereby increasing the risk of developing ketosis which can cause impaired neurological development of the fetus. So Edwards et al., in safety, recommend a weight gain of about 20 pounds to promote the most favorable outcome of pregnancy.

Gormican et al. (1980) studied two philosophies regarding optimal weight gain in pregnant women. One dominant philosophy before 1971 advocated limiting weight gain and even encouraged loss of weight in overweight women. After 1973, larger gains of about 24 pounds were recommended, even for those of greater prepregnancy weights. From each era, 301 cases were reviewed. Obese patients were defined as those 20% or more above standard weight for height according to the Metropolitan Life Insurance tables. Subjects tended to have higher weight for height in the more recent group. The "before 1971" group had a mean maternal weight gain of 15.9 pounds in the second and third trimesters with a 3329 gm average infant weight as compared to a 24.2 pound gain and 3450 gm infant weight for the later group. More broadly, the highest percentage of the restricted group fell into the 11 to 20 pound gain, while most subjects in the nonrestricted group fell into the 21 to 30 pound gain. If the Hytten and Leitch (971) figure of 3400 gm is used as

a standard for optimal birthweight, then the restricted group had mean birthweights lower than optimal. Therefore, Gormican et al. recommend a 20 to 30 pound gain, regardless of prepregnant weight status, since it results in optimal birthweights.

Luke and Petrie (1980) have a more complicated concept for determining optimal weight gain. Several variables should be considered because they believe that the concept that the fetus is an active efficient parasite and that its weight is directly proportional to maternal pregravid weight and gestational gain is simplistic and contrary to current knowledge of perinatal physiology. Most investigators have taken a one-sided view of the spectrum of the maternal pregravid weight, suggesting that gain in the underweight gravida will directly benefit fetal growth, and by the same mechanisms, gain in the obese gravida will result in "excessive" growth of the fetus. They point out that there are four factors in the maternal-fetal environment that should be taken into consideration: two dynamic energy drains and two potential energy sources. The maternal energy drain includes the cost of normal metabolic maintenance, and if present, correction of metabolic deficits (underweight, stress, smoking, concurrent disease). The fetal energy drain includes the metabolic costs of growth and development (more stable and predictable, Luke, 1984). The two potential energy sources include the endogenous reserve (maternal pregravid weight) and the exogenous supply (maternal gestational gain). Women of normal to minimal obese pregravid weight have a repleted endogenous supply that is divided between a normal

maternal maintenance and fetal growth. This represents optimal metabolic balance between maternal and fetal growth. With women of increasing obesity, the cost of normal maternal metabolic maintenance is set at a much higher level than for the nonobese gravida. It is added onto by an increase in BMR due to pregnancy. Therefore, a large percentage of the exogenous supply is diverted to the mother, with little remaining for the developing fetus. Consequently, suboptimal sources remain to meet the needs of the developing fetus. Increasing fetal growth retardation is seen. Perhaps the endogenous reserve is not readily utilized. It appears that the exogenous energy supply preferentially goes to the mother, before the newly developing tissue. So it seems disadvantageous to minimize weight gain in the obese. Luke and Petrie recommend that the obese reduce the excessive, endogenous reserve before gestation for an optimal outcome.

Naeye (1979) looked at the balance between energy drains and energy sources when he attempted to determine if a mother's prepregnancy nutritional reserves influence the partition of nutrients between her own and her fetus' tissues. Data from 53,518 pregnancies were used. Mothers were classified into underweight, normal weight, and overweight groups based on prepregnant weights of < 93 pounds, 93-118, and > 138 pounds for 61-64 inches in height. With underweight women, there was a 9.9% increase in birthweight from the lowest maternal weight gain category to the category where net gain was > 12 kg as opposed to a 1.4% increase in the normal and overweight mothers. This indicates that thin mothers partitioned a significantly greater proportion of ingested

nutrients to their own tissues at low weight gains than did heavier mothers and thin mothers with larger weight gains. The mother's nutritional status does make a difference. These findings add weight to Luke and Petrie's postulations of the exogenous supply preferentially going to the mother when she needs to correct for a metabolic deficit.

Luke et al. (1984) later supported these findings when they attempted to evaluate the influence of maternal height, as a possible indicator of preconceptional nutritional status and the gestational nutritional environment, on intrauterine growth. The researchers grouped the 696 patients according to delivery weight as a percent of ideal weight for height as follows: group I < 114%, group II 114.5%-124.4%, group III 124.5% to 149.4%, group IV > 149.5%. The groups were correlated to: group I underweight or inadequate maternal weight gain (< 15 pound); group II normal weight and/or adequate maternal weight gain (16-30 pound); group III, moderately obese and/or high maternal weight gain (31-50 pound), and group IV, massively obese and/or very high maternal weight gain (> 50 pound). All women were also grouped by height as short (< 5 ft. 2 in.), average (> 5 ft. 2 in. to < 5 ft. 6 in.) or tall (> 5 ft. 6 in.).

Higher pregravid weight and/or gestational weight gain among the gravidas of short stature produced the largest increase in birthweight. The data indicated that increasing maternal weight before pregnancy (higher pregravid weight) or during pregnancy enhances intrauterine growth in those gravidas whose short stature is the result of inadequate nutrition during the preconceptional period. Luke et al. suggested that

the absence of any severe growth retardation and the declining incidence of moderate growth retardation in the infants of short gravidas of the highest delivery weight indicates that most, if not all, of these women suffered from some degree of impaired nutritional status, rather than shortness being purely genetic.

They pointed out that there is also an upper limit above which increasing maternal obesity and/or gestational gain begins to exert a negative effect on intrauterine growth. The incidence of severe growth retardation was shown to increase from 0% (group II) to 1.5% (group III) to 2.5% (group IV). With increasing delivery weight percents, both moderate and severe excessive intrauterine growth fell (54.4% to 52.5% and 37.9% to 35% in groups III and IV) confirming that additional gestational weight gain is disproportionately diverted to the mother for her own maintenance, resulting in suboptimal energy sources remaining to meet the needs of the developing fetus. Therefore, it is important that women have adequate food intake (exogenous supply). In fact, if the weight of the mother before and during pregnancy reflects her nutritional status before pregnancy, the more important is her nutritional status during pregnancy. There may be minimum nutrient requirements which must be provided by the maternal diet and stores in order to ensure normal fetal growth and metabolic balance of the four previously mentioned factors. As stated before, below this level, fetal growth may be retarded. The relationships between ingested calories and birthweight appears to be curvilinear. As the prepregnant nutritional status approaches optimum levels, the efficiency of conversion of

ingested calories during pregnancy into birthweight decreases. The maternal stores buffer changes in maternal diet and serve as a protective mechanism. The pregnant woman can store them early in pregnancy and transfer these reserves to the fetus as needed. If the efficiency of storage and subsequent transfer is high, the effect of supplementation during pregnancy would be approximately the same regardless of when the supplementation is given. In other words, the total amount of ingested calories may be the main determinant of birthweight, and not the trimester when calories were ingested (Lechtig et al., 1975).

Phillips and Johnson, 1977, studied food intake in the last four months of pregnancy of 47 women and its relationship to birth weight. Specifically, protein, Ca, Fe, vitamin A, thiamin, riboflavin, niacin, vitamin C, Mg, pantothenic acid, vitamin B6, and vitamin B12 were estimated from food records. They found a significantly positive correlation ($p < 0.05$) between birthweight of the infant and overall quality of the mother's diet. Dietary data did not show any detectable changes in nutrient intake from the 22nd week to the end of pregnancy.

We should be aware of the fact that maternal gain is affected by many factors in addition to energy intake, not the least of which is the individual's efficiency of energy utilization. Therefore, attempts to manipulate pregnancy weight gain through dietary means, including supplementation, will meet with variable success (Picone and Allen, 1982).

Pattern of Fat Deposition for Normal Weight and Overweight Gravidas

As stated before, due to changes in body composition and weight, it is known that a healthy pregnant woman lays down a large amount of fat, predominantly during midgestation, but in what location and how much? Much of the fat seems to be deposited subcutaneously (Taggert et al., 1967). In predicting birthweight of an infant, the fat-free weight of the mother and her weight of fat are used. Therefore, a measure of fatness technically independent of weight, such as triceps or subscapular skinfold, would provide more information than a weight derived measure (Garn and Pesick, 1982). In addition, subcutaneous fat thickness may be measured reliably and highly correlated with total body fat and percent of body weight that is fat (Himes et al., 1980). It differentiates between weight gain caused by an increase in muscle or bone and weight gain due to an increase in fat (Womersley, 1977). Because skinfolds as a measure of skinfold fat thickness are relatively easy to quantify and require little equipment (as opposed to body density measures), the technique is widely used (Himes et al., 1980).

However, skin compression is a complicating factor in the use of skinfold measurements. Clearly, subcutaneous tissues are compressed when measured with skinfold calipers, and this compressibility probably varies with age, sexes, sites of measurement, and among individuals. Consequently, skinfolds always underestimate actual subcutaneous fat thickness and underestimate "true" cross-sectional fat areas. The question is whether taking compression into account makes an appreciable

difference in the efficacy of skinfolds and fat areas in estimating body fatness (Himes et al., 1980).

Taggert et al. (1967) attempted to determine at what sites and how much fat is deposited during pregnancy using skinfolds. They measured skinfolds in 84 healthy pregnant women in seven sites: triceps, biceps, scapula, costal, suprailiac, midthigh, and kneecap at 10, 20, 30, and 38 weeks. Total body water was measured in half of the women.

At all sites except the knee, there was an appreciable increase between 10 and 30 weeks. The proportional increase was by far the greatest at the suprailiac site, with moderate proportional increases at the scapula, costal, midthigh, and biceps, but little or no change at triceps and knee. In general, the greater increases were seen at central sites more so than at peripheral sites.

The patterns from 30 to 38 weeks of pregnancy were variable. The midthigh skinfold continued to increase, and costal and triceps decreased. Other sites showed little change. There was an overall decrease of surprisingly large dimensions from the 38th week until one week postpartum. These patterns do correspond to pattern of fat deposition during pregnancy.

Relatively obese women had smaller increases in skinfolds during pregnancy than relatively thin women. Increments in the sum of skinfold (TSF) measurements during pregnancy were greatest in those subjects with smallest initial skinfolds as they were repleting nutritional reserves. Also increases in skinfolds appeared to be slightly less among multipara. TSF increased in roughly the same manner as both total

weight and dry weight up to 30 weeks. Total weight continued to increase rapidly from 30 to 38 weeks, whereas dry weight increased only slightly and TSF showed a small decrease. The small increase in dry weight may be largely attributable to the growth of the product of conception, which more than compensates for the small decrease in maternal fat reserves. The occurrence of edema was not associated with any consistent alteration in pattern of skinfold change.

Pipe et al., 1979, also looked at the changes in fat, fat-free mass, and body water in normal pregnancy in 27 pregnant women within 20% of their expected weights. Body weight, total body water, skinfold thickness and fat cell diameter were measured on each of 3 occasions: 10-14 weeks, 24-28 weeks, and 36-38 weeks of pregnancy. Skinfold measurements were taken at biceps, triceps, subscapula, and suprailiac and summed. Greatest weight gain was seen between the first and second measurements (10 and 26 weeks). Total water increased by 7.2 ± 0.48 kg between 10 and 37 weeks. Maternal fat increased rapidly after the first measurement (10-14 weeks), reached its maximum observed value at 24-28 weeks, and thereafter fell slightly during the remainder of pregnancy. There was no net accumulation of fat in the last three months of pregnancy. In fact, there was an apparent loss of 0.54 kg (not significant). Increases in fat free mass and excess water were delayed in relation to an increase in body fat and maximum values of these components were seen at the third measurement in late pregnancy (36-38 weeks). Skinfolds and fat cell diameter increased rapidly between 12

and 26 weeks similar to body fat. So most of the fat deposition is in the second trimester, as seen by Taggert et al. (1967).

Summary

In summary, little research has been published concerning the obese gravida. Most studies have been conducted with the underweight and normal weight gravida from which investigators have recognized that weight gain and pregravid weight are the two strongest influences on the birthweight of the infant (Luke and Petrie, 1980). For the normal weight gravida, a weight gain of 22 to 27 pounds is the recommended amount for producing an infant of optimal birthweight. The ideal weight gain for the obese woman is still under question.

Due to increased maternal nutritional reserves, obese women may not need to gain as much weight for an optimal pregnancy outcome. Naeye (1979) found that women with prepregnant weights 135% of desirable weight had the lowest perinatal mortality rates when their gains were 24 to 54% of optimal values. Similarly, Edwards et al. (1978) found that even though there was an increased incidence of inadequate gain in obese women, there was a lower incidence of LBW infants. However, Gormican et al. (1980) found that with lower weight gains the obese gravida had more LBW babies. Nevertheless, all researchers recommended a 20 to 30 pound weight gain, regardless of prepregnant weight. Their reasons were: 1) maternal reserves may not supply the quantity and balance of nutrients favorable to the fetus that a nutritionally adequate diet would, and 2) the cost of pregnancy is still 80,000 kcal, and any less consumed suggests ketosis. Luke and Petrie (1980) support the liberal weight gain since they believe that an obese woman has a higher cost of maternal maintenance than a normal weight woman. Since the exogenous

supply preferentially goes to the mother, the fetus can suffer if the mother does not have a high enough caloric intake. In essence, the maternal stores should really act as a buffer for changes in maternal diet and serve as a protective mechanism rather than the predominant energy supply.

Skinfold measurements have been used to determine the amount of fat deposition and utilization during pregnancy. From this data investigators have found that fat stores do increase predominantly at the body's central sites from the 10th to 30th weeks of gestation. Obese women have smaller increases in fat deposition due to their larger stores than nonobese women initially.

MATERIALS AND METHODS

General Experimental Design

Weight, skinfold, and circumference measurements were made on 51 healthy Caucasian pregnant women between 20 and 38 years of age, every four weeks (± two weeks) from the 12th until the 24th week of gestation (the second trimester). Skinfold measurements were taken at eight sites: triceps, subscapula, midaxillary, suprailiac, abdominal, midthigh, knee, and calf. Circumference measurements were also taken at eight sites: bust, waist, hips, thigh, calf, ankle, upper arm, and wrist. Height was measured at the first appointment. Blood pressure and urine sample readings were taken for precautionary reasons. Prior to each visit, the women completed 72 hour food records (Appendix A). No changes in food habits or lifestyle were necessary for participation. No nutritional advice was given unless asked. Descriptive information was collected from six questionnaires: medical history (Appendix B), sociodemographic (Appendix C), food and health habits (Appendix D), exercise and activity level (Appendix E), and food knowledge and beliefs (Appendix F), which were filled out during the initial interview.

Recruitment of Subjects

Flyers providing the basic information about the study were posted at strategic locations around the campus of Virginia Polytechnic Institute and State University as well as the community of Blacksburg (Appendix G). Several local physicians agreed to support the study by

distributing the flyers in their office. Spas, grocery stores, churches, apartment complexes, and area businesses were targeted. In addition, advertisements were placed in the New River Valley section of The Roanoke Times and in The Spectrum, the faculty, staff, and graduate student newspaper. Active recruitment lasted approximately six months.

Persons interested in the study were requested to call the investigators for further information. Information concerning the study was given during the initial telephone contact. At that time subjects were then scheduled for their first appointment to complete descriptive questionnaires and to be measured.

Screening of Subjects

Initially, the women were screened for gestational age during the telephone contact, as determined by the number of weeks since the first day of their last menstrual period. It was preferred that they not be beyond twelve weeks; however, women were accepted up until their 20th week of pregnancy, as it was often difficult to identify women as subjects at the earlier time.

At the first appointment, a written (Appendix H) and oral explanation of the study were given. Confidentiality was assured, potential risks were explained, compensation was noted, and any questions were answered. A consent form (Appendix I) was then signed.

As determined from the questionnaires and interview, women were eliminated as potential subjects if: they had diabetes or any other complication affecting metabolism; they were cigarette smokers; they

habitually consumed alcohol and/or recreational drugs; they would not be able to make all of the appointments; they were < 20 years or > 38 years of age; they were not Caucasian. Later, subjects' data were eliminated from analysis if they delivered twins or premature infants (< 37 weeks).

Description of Study Participants

There were 51 caucasian, healthy, pregnant females between the ages of 20 and 38 (mean = 27.9 ± 4.15 years) who participated in the study. Data for five women were eliminated from analysis since four delivered prematurely and one delivered twins. Classified according to the guidelines in the RDA Handbook (1980), seventeen women were overweight ($\geq$ 110% of desirable weight for height) and 29 were of normal weight prior to pregnancy. The women on the whole had a mild activity level (as evidenced by limited sweating). All the women had at least a high school education; all but three obtained additional education. The majority (65%) worked outside of their homes; the average annual gross family income being $24,373.48 which supported an average of 2.8 people. Most of the women lived in a minor urban community ($\geq$ 2,500 and < 100,000 people).

Procedures for Obtaining Weight and Height

Weight was measured with a single beam balance which had been calibrated for accuracy. The subject was dressed in a paper examination gown with no shoes. The balance was read to the nearest 0.01 kg.

Height was taken using the bar attached to the single beam balance. The subject, without shoes, stood tall and straight with heels together. Shoulders were relaxed and sloping forward, with eyes positioned straight ahead. Pressure was applied to the headboard to ensure that hair was not being measured. The counter was read to the nearest 0.05 cm.

Procedures for Obtaining Skinfold Measurements

Skinfolds were measured on the dominant side of the body using a calibrated LANGE skinfold caliper (Cambridge Scientific Industries, Cambridge) with a standard pressure of 10gm/sq.mm. With the subject's muscles relaxed and body erect, the skinfold was grasped by the investigator between the thumb and forefinger of the left hand and held until the measurement was taken. The skinfold included two thicknesses of skin and subcutaneous fat, but not muscle. With the right hand, the calipers were applied approximately one centimeter below the fingers holding the skinfold, at a depth equal to the thickness of the fold. Each fold was taken in the vertical plane while the subject was standing, except for the subscapular and suprailiac which were picked up on a slight slant running laterally in the natural fold of the skin. The measurement, recorded to the nearest 0.5 mm, was repeated three times at each site to insure precision and accuracy. The anatomical landmarks for the skinfold sites are as follows:

Triceps - the back of the upper arm midway between the shoulder and elbow joint. (Subject bends arm at right angle, so the midpoint can be measured and marked with a pen. Then with the subject's arm relaxed at

her side, a lengthwise double fold of skin and fat was grasped about 1 cm above the mark and measured as stated above. This insured that the pressure at the midpoint was exerted by the calipers and not the fingers.

Subscapula - the bottom of the shoulder blade.

Midaxillary - the middle of the side, level with the lower end of the sternum.

Suprailiac - just above the iliac crest at the middle of the side of the body.

Abdomen - approximately two centimeters to the side of the navel.

Thigh - the middle front side of the thigh, midway between the hip and knee.

Knee - two centimeters above the patella.

Calf - two inches below the crease behind the knee, midway across the leg.

Procedures for Obtaining Circumference Measurements

A metal tape was used to avoid inaccuracy due to stretching. The tape was held in contact with the skin without constriction. The dominant side was measured at the bilateral anatomic sites while the patient was standing. The anatomical landmarks are as follows (Getchell, 1983):

Bust - at the nipple line at the midpoint of normal breath.

Waist - at the minimal girth, below the rib cage and just above the top of the hip bone.

Thigh - at the crotch level, just below the gluteal fold.

Calf - at the maximal circumference.

Ankle - at the minimal circumference, above the ankle bones.

Upper arm - at the midpoint of the shoulder and elbow.

Wrist - at minimal circumference.

Hips - at the largest protruding part of the buttocks.

Blood Pressure Procedure

The subject sat upright, was comfortable, and was in as calm a state as possible. Blood pressure was taken on the right arm. The cuff was secured on the arm, the cuff was pumped to 160 mm HG while the stethoscope was placed on the elbow crease. The pressure was slowly released and at the first point the sounds were heard, the number was recorded as the systolic reading and then the number at the point of disappearance as the diastolic reading. In some subjects, the point of muffling of the sound was recorded as the diastolic pressure if sounds could be heard until the mercury approached zero.

Urine Analysis

The urine was collected in a clean dry plastic cup and tested as soon as possible. One strip was taken from the bottle of Bili-Labstix (Ames Division of Miles Laboratories, Indiana), and the reagent areas were completely immersed. The strip was removed immediately to avoid dissolving the reagents. The edge of the strip was held against the side of the container to remove excess urine. The strip was then held

in a horizontal position to prevent possible mixing of chemicals from adjacent reagent areas. The test areas were compared to the corresponding color charts on the bottle label at the times specified. PH and protein were read up to one minute after dipping. The glucose was read at 30 seconds and ketone at 15 seconds. However, all areas could have been qualitatively read between one and two minutes.

Statistical Analysis

The means and standard deviations were determined for each measurement for each period for both the normal weight and overweight groups. T-tests were then completed to test for significant differences at a level of at least $p < 0.05$.

Least square estimates were determined to obtain the average amount of change for each measurement per four week period.

A multiple linear regression test was used to determine if there was a relationship between weight gain and age of the mother with the birthweight of the infant.

The Department of Experimental Statistics at Louisiana State University analyzed the data from the food records to determine nutrient content and percentages of the recommended dietary allowances.

RESULTS

Seventeen of the subjects were classified as overweight (m = 66.87 ± 6.83 kg) as they were 110.2 to 151.2 percent of their desirable weight for height (RDA Handbook, 1980). The remaining 29 were classified as normal weight (m = 55.11 ± 4.53 kg) as they were 85 to 109.7 percent of desirable weight for height.

The average circumference, skinfold, and weight measurements at each of the four measurement periods (12-14, 15-18, 19-22, and 23-26 weeks) were significantly greater ($p < 0.05$) for the overweight women than for the normal weight women in almost every case (Tables 2, 3 and 4). The exceptions were the midaxillary and abdominal skinfolds at the first period, the knee skinfold at the second and fourth periods, and the calf skinfolds at all periods.

The difference in the average amount of change in measurements over a four week period is shown in Table 5. There was a significant increase in weight for both groups (2.086 kg/4 weeks, $p < 0.0001$). There was a significant increase in the bust, waist, and hip circumferences and the suprailiac skinfold measurements for the normal weight women ($p < 0.0001$). There were appreciable increases in midaxillary skinfold and thigh circumference measurements, though not significant. For the overweight group there was a significant increase in bust and waist circumference measurements ($p < 0.001$) and a significant decrease in abdominal skinfolds ($p < 0.05$).

Table 2. The mean of each circumference measurement for each period for normal weight versus overweight gravidas.

Sites	Week (± 2 weeks)	NORMAL WEIGHT mean	SD	n	OVERWEIGHT mean	SD	n
bust	12	85.64	4.80	15	93.44	4.58	7
	16	87.63	3.94	26	96.81	5.51	14
	20	88.52	3.79	29	98.04	4.92	17
	24	89.68	3.97	29	99.52	4.87	17
waist	12	71.84	4.09	15	76.93	4.18	7
	16	74.82	4.08	26	83.57	5.29	14
	20	77.66	4.69	29	86.39	4.06	17
	24	82.44	5.25	29	90.43	4.51	17
hips	12	91.80	3.52	15	99.77	4.63	7
	16	94.04	3.48	26	101.01	4.43	14
	20	94.83	3.55	29	102.41	4.12	17
	24	96.21	3.96	29	102.84	4.34	17
thigh	12	52.81	3.28	15	57.90	2.02	7
	16	53.58	3.82	26	58.31	4.23	14
	20	53.71	3.90	29	58.54	3.29	17
	24	54.31	4.63	29	59.76	3.54	17
calf	12	33.27	1.78	15	36.37	1.81	7
	16	33.84	1.71	26	37.36	2.41	14
	20	34.07	1.97	29	37.55	2.15	17
	24	34.12	1.90	29	37.34	2.34	17
ankle	12	20.41	1.10	15	21.57	0.91	7
	16	20.73	1.45	26	21.89	0.98	14
	20	20.82	1.55	29	22.19	1.23	17
	24	20.75	1.28	29	22.07	1.31	17
upper arm	12	24.95	1.40	15	28.59	2.42	7
	16	24.94	1.48	26	28.83	1.97	14
	20	25.06	1.54	29	28.97	2.08	17
	24	25.23	1.53	29	28.95	1.96	17
wrist	12	14.77	0.67	15	15.64	0.97	7
	16	15.05	0.63	26	15.85	1.08	14
	20	14.99	0.76	29	16.07	1.27	17
	24	14.98	0.71	29	15.98	1.11	17

Table 3. The mean of each skinfold measurement for each period for normal weight versus overweight gravidas.

Sites	Week (± 2 weeks)	NORMAL WEIGHT mean	SD	n	OVERWEIGHT mean	SD	n
Skinfold:							
triceps	12	18.66	5.65	15	26.00	4.92	7
	16	18.40	5.06	26	24.89	5.65	14
	20	19.03	4.16	29	25.12	6.39	17
	24	18.78	4.16	29	25.62	6.41	17
Subscapula	12	14.86	5.33	15	19.71	3.39	7
	16	15.08	5.39	26	22.82	6.99	14
	20	15.02	4.05	29	22.68	6.87	17
	24	14.74	3.48	29	22.65	6.86	17
suprailiac	12	22.23	8.28	15	32.79	3.83	7
	16	26.46	7.43	25	36.25	7.04	14
	20	29.07	6.51	29	37.21	6.65	17
	24	31.48	6.93	28	21.56	7.30	17
midaxillary	12	13.46	4.99	12	14.67	2.56	6*
	16	13.51	4.36	26	21.46	8.18	14
	20	13.62	4.14	29	21.38	8.28	17
	24	13.45	2.62	28	21.56	7.30	17
abdominal	12	18.23	7.27	15	20.86	6.16	7*
	16	19.73	7.36	26	27.07	8.25	14
	20	18.42	5.92	29	25.00	7.74	17
	24	17.10	5.04	29	21.00	7.45	17
thigh	12	27.97	6.88	15	34.50	6.08	7
	16	28.51	5.51	26	35.32	8.09	14
	20	29.07	5.69	29	34.85	6.47	17
	24	29.55	6.31	29	34.76	7.63	17
knee	12	21.43	5.13	15	27.07	7.91	7*
	16	22.52	4.91	26	27.39	9.87	14*
	20	22.02	4.44	29	28.03	8.81	17
	24	23.10	5.25	29	25.40	8.30	17
calf	12	20.10	5.20	15	23.14	7.65	7*
	16	21.86	5.99	26	25.21	9.15	14*
	20	20.86	6.21	29	20.62	8.38	17*
	24	20.41	6.26	29	21.59	7.58	17*

* not significantly different at $p < 0.05$

Table 4. The mean values for weight for each 4 week period for normal weight versus overweight gravidas.

	Week (± 2 weeks)	NORMAL WEIGHT mean	SD	n	OVERWEIGHT mean	SD	n
weight	12	54.79	3.13	15	64.76	3.40	7
	16	57.65	4.78	26	69.64	5.92	14
	20	59.52	4.78	26	71.61	5.86	17
	24	61.43	5.11	29	73.49	6.11	17

Table 5. The average amount of change in anthropometric measures per four week period.

	Normal weight	Overweight
weight (kg)	2.086*	2.086*
triceps (mm)	2.236	2.449
subscapula (mm)	9.694	4.287
suprailiac (mm)	39.480*	3.420[c]
midaxillary (mm)	17.056	-4.290
abdominal (mm)	-6.119	-16.791[b]
thigh (mm)	2.429	-2.371
knee (mm)	3.515	-7.440
calf (mm)	-2.333	-7.461
bust (cm)	12.887*	16.752[a]
waist (cm)	38.488*	38.993*
hips (cm)	13.908*	10.887[c]
thigh (cm)	5.419	3.923
calf (cm)	1.757	1.405[c]
ankle (cm)	0.217	1.344
upper arm (cm)	1.571	1.138[c]
wrist (cm)	0.132	1.098

* significant change $p < 0.0001$
a significant change $p < 0.001$
b significant change $p < 0.05$
c r square > 0.90 significantly different change

The amount of change in the bust and waist circumferences and weight was not significantly different ($r < 0.50$) for the overweight versus the normal weight women; it was merely a difference in initial values. However, there was a significantly greater change ($r > 0.90$) for the suprailiac skinfold and the hip, calf, and upper arm circumference for the normal weight women versus the overweight women.

The mean caloric intake for the normal weight and overweight gravidas was 2312.12 ± 461.43 (100.53% of RDA) and 2473.05 ± 503.12 calories (107.52% of RDA) respectively. These values are not significantly different. The gram values for protein, fat, and carbohydrate, along with their corresponding percentages in the diet are listed in Tables 6 and 7. Again, there is no significant difference between the two groups.

A multiple linear regression test did not show a clear relationship of weight gain in the second trimester and the age of the mother with the birthweight of the baby of the overweight or normal weight gravidas (R square values being 0.173974 and 0.028739 respectively).

The average weight of the babies born to normal weight gravidas was 3526.14 ± 448.97 gms as compared to 3521.19 ± 635.30 gms for those born to overweight mothers. There was only one LBW infant (2400.57 gms). The mother's prepregnant weight was 151% of her desirable weight for height.

In addition, three of the four women who were excluded from analysis due to premature delivery were classified as overweight (128.9%, 129.5%, and 149.8%) of desirable weight for height).

Table 6. The mean nutrient intake values for normal weight versus overweight gravidas as determined from 72 hour food records.

	Normal weight	Overweight
	n=29	n=17
Calories	2312.12 ± 461.43*	2473.05 ± 503.12*
% RDA	100.53	107.52
Protein gm	86.002 ± 18.71*	91.06 ± 19.64*
% RDA	116.24	123.05
Fat gm	102.25 ± 23.95*	99.24 ± 24.50*
Carbohydrate gm	276.12 ± 60.10*	312.45 ± 107.15*

* mean ± S.D.

Table 7. The percentage of protein, fat, and carbohydrate in the diet of normal weight versus overweight gravidas as determined from 72 hour food records.

	% of Diet	
Nutrient	normal weight	overweight
Protein	14.8%	14.7%
Fat	39.8%	36.1%
Carbohydrate	47.7%	50.5%

DISCUSSION

The midaxillary and abdominal skinfold measurements may not have been significantly greater for the overweight gravida in the first period due to the smaller population at that time. Only seven of the total seventeen overweight women were available for measurement at that time. The variations in the knee measurements may be due to the difficulty in insuring that the leg was relaxed for that measurement. If the leg was flexed even slightly, a smaller skinfold measurement would result.

A significant increase in weight during the second trimester was expected, even though it was more than the amount cited by Hytten and Leitch (1971) (2.086 kg versus 1.44-1.8 kg/4 week period). However, the same increase for the overweight and normal weight women was not expected, as Edwards et. al. (1978), Harrison et. al. (1980), and Calandra et. al. (1981) all noted inadequate gains in overweight gravidas. The discrepancy may be due to the overweight group being too close in weight to the normal weight group. Inadequate gains may only be of concern when women are > 150% of their desirable weight for height.

On the average, the gravidas of both groups consumed approximately the same number of calories. They were well nourished as they satisfied the recommended dietary allowances for calories and protein, however, their weight gain was much higher than Hytten and Leitch's cited amount. A probable reason is decreased exercise, as most had a very mild activity level. Another explanation is that the food records may have

underestimated the actual food consumption levels. Even though the investigators reviewed the records for accurate descriptions of food items and the subjects were careful of recording typical days, some women did have difficulty estimating portion size and others became weary of completing the food records. Therefore, women may have decreased their food intake to make completion of the records easier and less time consuming. As a result, the food record data should be considered as an estimation.

As Taggert et. al. (1967) observed, greater increases were seen at the central sites: bust, waist, hips circumferences and midaxillary and suprailiac skinfolds than at the peripheral sites. In addition, greater increases were seen in the normal weight gravida than in the overweight gravida, presumably since they have a greater need to replete their nutritional reserves. A greater decrease in abdominal skinfold measurements for the overweight group was expected since they had larger skinfolds initially to be stretched taut.

Using the dependent variables prepregnant weight and the age of the mother to predict the appropriate weight gain during pregnancy to yield desirable birth weight is not adequate. There must be other determining factors that need to be taken into consideration.

Both groups yielded infants with optimal mean birthweights which were not significantly different from each other. The insignificant difference in birthweights for the two groups may be a result of the overweight group not being overweight enough. For instance, only when

the data for the heaviest of the gravidas (151% of desirable weight for height) on the study is looked at singly, a suboptimal birthweight for her infant is noted.

CONCLUSIONS

There does appear to be a wide range of weight gains for varying prepregnant weights which allow for clinical normality. This study needs to be extended to a larger sample of pregnant women in order to define more precisely the desirable relationship of prepregnant weight and gestational gain to promote optimal outcomes of pregnancy. Until then, it is encouraged that pregnant women have a liberal weight gain of 20 to 30 pounds. Those gravidas who are approximately 150% of desirable weight for height may need to gain on the lower end of the spectrum (20 pounds) since with larger gains there is a higher risk of LBW infants-mostly due to preeclampsia. The cost of pregnancy is still 80,000 kcal and any less consumed suggests ketosis. The overweight woman needs just as much or more caloric intake to support a higher cost of maternal maintenance. Since the exogenous supply preferentially goes to the mother, the fetus can suffer if the mother has an inadequate intake and weight gain. Furthermore, the maternal stores should act as a protective mechanism rather than as the predominant energy supply.

SUMMARY

Weight, skinfold and circumference measurements were obtained from 29 normal weight and 17 overweight healthy pregnant women every four weeks during their second trimester of pregnancy. The mean weight gain and food intake per four week period were approximately the same for both groups. Measurements increased at a greater rate for the normal weight women versus the overweight women. Presumably, this is due to the repletion of the nutritional reserves of the normal weight women. Increases in the skinfold measurements were greater at central sites than at peripheral sites. The infant birthweights of both groups were all at an optimal level ($>$ 2500 gm) except for one (who was born to the gravida 151% of desirable weight for height). The similarity in results for the two groups is greatly due to the fact that there was not a large enough difference in weights between the two groups. The results do lend support to the view of investigators who advocate a 20 to 30 pound weight gain for healthy pregnant women with a wide range of prepregnancy weights. Due to the increased nutritional reserves and possible harm to the fetus of those with large weight gains, obese women (150% of desirable weight for height) may need to gain on the lower end of the spectrum.

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APPENDIX A

FOOD RECORD

Subject's Name:_____

Date_____

Instructions for Completing a 3/day Food Record

Included is a food record chart. The information you provide in the following pages will be used to help tell us the composition of your diet. With these values, your weight gain and body measurements, we will attempt to assess which nutrient reserves supply deficient nutrients and store excess nutrients.

It is important that you be as specific and accurate as possible in recording your food intake. Instructions for recording your meals are as follows: (Please refer to the attached example chart.)

1. List the time of day you eat a snack or meal.

2. Next list the items of food you ate. Please break each food into the components it is made of: eggs, skim milk, salt, pepper, etc.

3. List the amounts that you ate: 2 eggs, 3 tablespoons of margarine. Be sure to include any foods used in preparation.

4. List how it was prepared: eggs scrambled or fried in 2 tablespoons of margarine. Be sure to include any foods used in preparation.

5. If you ate a fast food, list where you ate it next to the item (Wendy's, Mcdonald's).

Below are some questions to help you complete the form without forgetting any foods or making an error in serving size. It may help you to tape the record sheet to your refrigerator door so you may fill out the chart as you prepare your meals and snacks.

1. Do you usually eat or drink something before your morning meal? If so, list this.

2. Do you snack throughout the day? If so, list all snacks.

3. Do you periodically purchase snacks from vending machine? Include these: gum, candy, etc.

4. Remember to list condiments like ketsup, mustard, relish. These are important food sources.

5. Define the type of foods you eat; if you drink milk, is it skim, 2%, whole, chocolate?

6. If possible, list foods like sandwiches and casseroles separately; ham and cheese sandwich--2 pieces of whole wheat bread, 1 tablespoon mayonnaise, 1 leaf iceburg lettuce, 2 oz. ham, 2 oz. swiss cheese.

7. You can't be too specific! List anything you think will help us--the type of juice, coffee. If you have any questions, don't hesitate to call!

APPENDIX A
(Continued)

SAMPLE FOOD RECORD

Subject #_____

Date_____

Time	Food Item	Amount	How Prepared
8:00 a.m.	skim milk	1 cup	
	orange juice	6 oz.	
	eggs	2	scrambled with:
	skim milk	3 T.	
	margarine	2 T.	
	salt	dash	
	pepper	dash	
9:15 a.m.	white bread	1 slice	toasted, plain
11:30 a.m.	yogurt, lowfat strawberry	1 cup	
	banana	1 med.	
	rye crisp crackers	4	
	Iced tea	8 oz.	
	sugar	1 tsp.	

APPENDIX B

MEDICAL HISTORY

Subject #_____

Date_____

1. Do you have an illness or condition (other than being pregnant) that requires regular medical care? 1 = yes; 2 = no

   A. Allergies ____
   B. Specific food allergies ____
   C. Asthma ____
   D. Respiratory problem ____
   E. Kidney problem ____
   F. Stomach or gastrointestinal problem ____
   G. Other, specify _____

2. Do you take any drugs or medications regularly? (1 = yes; 2 = no)____

3. If you answered yes to question 2, then specify: 1 = yes; 2 = no) ____

   A. Antihistamines ____
   B. Aspirin ____
   C. Aspirin substitutes ____
   D. Tranquilizers ____
   E. Vitamins and/or minerals ____
   F. Other, specify _____

4. Among your brothers, sisters, parents, aunts, uncles, or grandparents is there a known cause of: 1 = yes; 2 = no

   A. Heart attack ____
   B. Stroke ____
   C. High blood pressure ____
   D. Hardening of arteries ____
   E. High blood cholesterol or triglycerides ____
   F. Diabetes ____
   G. Cancer ____

5. How old were you when your menstrual periods started? (age in years and month ____

6. Have you ever had menstrual complications (i.e., ammenorrhea)

   What _____

   When _____

7. Are your menstrual periods regular? (1 - yes; 2 = no) ____

8. How long do your periods last? (number of days) ____

9. How many days lapse from period to period? ____

10. Before becoming pregnant did you take medication for:
    (1 = yes; 2 = no)

    A. Pain related to menstruation ____ Specify _____

    B. To control regularity or flow of menstruation_____

       Specify_____

11. Have you ever taken birth control pills? (1 = yes; 2 = no) ____
    If yes, answer A-C.

    A. How long have you used birth control pills? ____months

    B. Were you taking birth control pills when you became pregnant?
       ____

    C. If the answer to "B" is "no", how long before becoming pregnant had you stopped taking them?
       ____ # of months

12. How often do you smoke cigarettes? ____
    Record # of cigarettes smoked per day. If never, record "0".

APPENDIX C

SOCIO-DEMOGRAPHIC BACKGROUND INFORMATION

Subject #_____

Date _____

1. In which of the following locations do you live?

   1. Major urban - 100,000
   2. Minor urban - 2500 but , 100,000
   3. Rural, non-farm - 2500 and non-farming
   4. Rural, farm - 2500 and farming

   Code subject's residence to the right _____

2. How many years of schooling have you completed? (Check the highest level of education completed.)

____ 0-5	____ technical or vocational
____ 6-8	____ some college
____ 9-11	____ completed college
____ completed high school	____ graduate school

3. Are you employed outside the home? (1 = yes; 2 = no) ____

4. If employed, do you work? (1 = full-time; 2 = part-time) ____

5. If employed, what is your occupation?

   Note: Refer to Table of Occupations: Levels and Kinds to obtain code for reply to this question.

1 = Professional	5 = Blue Collar
2 = Proprietor	6 = Service
3 = Business	7 = Farm
4 = White Collar	8 = Other

6. What is your marital status? ____

1 = married	4 = separated
2 - widowed	5 = never married
3 = divorced	

7. What is the total number of persons living in your household? ____

8. Who lives in the household with you (Check the appropriate category and record the actual number)

____husband of subject	____grandfather(s)
____children of subject	____male cousin(s)
____father	____female cousin(s)
____mother	____niece(s)
____brother(s)	____nephew(s)
____sister(s)	____mother-in-law
____uncle(s)	____father-in-law
____aunt(s)	____other(s), specify_____
	_____

Note: From the following information obtained in question 8, determine the family type as follows:

If the family consists of subject and husband, Family Type 1.
If the family consists of subject, husband, and children, Family Type 2.
If the family consists of subject and children, Family Type 3.
If the family consists of subject, husband, and others, Family Type 4.
If the family consists of subject only, Family Type 5.

Family Type ____

9. How many years of schooling has your husband completed? (Check the highest level of education completed.)

____0-5	____technical or vocational
____6-8	____some college
____9-11	____completed college
____completed high school	____graduate school

10. Is your husband employed? (1 = yes; 2 = no) ____

11. If employed, is it: (1 = full-time; 2 = part-time)? ____

12. If employed, what is his occupation? _____
(Note: Refer back to Table of Occupations for correct code.)

13. If not employed, is your husband

1 = unemployed
2 = retired
3 = student
4 = homemaker _____

Note: For the following questions, please indicate to the subject that the period for reporting income is the past 12 months.

For all sources of income below, the following codes are to be used: 1 = yes; 2 = no.

14. We need to relate information on food habits, meal practices, and health to your sources of income. To keep this completely confidential, I would like you to indicate which of the following ways your household received income last year?

A.	Wages, salary, and/or bonus	_____
B.	Social security, veteran's pension (not welfare), or insurance payments	_____
C.	Farming	_____
D.	Rental property	_____
E.	Welfare payments	_____
F.	Child support	_____
G.	WIC	_____
H.	Food stamps	_____
I.	Gifts (friends, relatives)	_____
J.	Business	_____
K.	Odd jobs or any other source	_____

15. Now that you have noted the source(s) of your family income, what is the total income (add all your sources) before taxes are deducted? You can do this by week, month, or year.

$_____weekly
$_____monthly
$_____yearly

** if listed weekly or monthly ask question #16.

16. How many weeks or months of the year do you make this amount?

_____weeks
_____months

17. Given the above information in question 15 and 16, what is the subject's total gross family income?_____

18. How may people does this income support?_____

APPENDIX C
(Continued)

TABLE OF OCCUPATIONS

GROUPS:	Lawyer; judge; physician; engineer; professor; school superintendent; teacher; librarian; registered nurse; minister; entertainer
PROPRIETOR:	Proprietors of large and small businesses
BUSINESS:	Executive; manager or supervisor of office, department, branch office or bank; buyer and salesman of merchandise.
WHITE COLLAR:	CPA; editors; writer; executive secretary; secretary; stenographer; insurance or real estate agent; stock broker; bank teller or clerk; ticket agent; store clerk
BLUE COLLAR:	Small contractor; foreman; master carpenter; electrician; skilled factory worker
SERVICE:	Police; R.R. conductor; barber or cosmetologist; practical nurse; domestic service worker; food, beverage, and lodging worker; amusement and recreation worker; laundry, dry clean or furnishing worker; building maintenance worker, janitor
FARM:	Farmer or landowner; farm and land supervisor or operator; operator of leased property; tenant on farm; migrant worker; forestry; share cropper

APPENDIX D

FOOD and HEALTH HABITS

Subject's #_____

Date_____

1. How many times per week do you usually take nutritional supplements such as vitamins, minerals, or protein in addition to the foods you eat?

   Circle one: 0 1 2 3 4 5 6 7

2. If you take supplements, who recommended that you take the supplements? (select one)

   1. Physician
   2. Self
   3. Media
   4. Friend(s)
   5. Husband

3. What supplements did you take yesterday? How many capsules or tablets, and at what time were they taken?

Supplement Name	Concentration of Tablet	Frequency	Time of Day

4. When you eat/drink snacks do you eat or drink them:

   1 = Never; 2 = Sometimes; 3 = Often

   a. Because you are hungry? _____
   b. To be social or part of a social activity _____
   c. Just to have something to do? _____
   d. Because you see something that looks good? _____
   e. To gain weight? _____
   f. Other reason _____

5. Are you presently on a vegetarian diet? yes = 1; no = 1 _____

6. As a vegetarian do you eat: yes = 1; no = 2

   a. eggs____
   b. milk____
   c. cheese____
   d. fish____

7. Are you a vegetarian for (circle one)

   1. religious reasons
   2. humanitarian reasons
   3. dislike
   4. economic reasons
   5. health reasons
   6. lifestyle

8. How long have you been a vegetarian? _____ (specify in months)

9. Have you even been on a weight reduction diet?_____
   yes = 1; no = 2 If answer is No ship to questions #14.

10. If yes, was it recommended or decided on primarily by:
    (select one)

    1. Physician
    2. Family members (other than husband)
    3. Self
    4. Friend(s)
    5. Husband
    6. Media

11. Have you been on a weight reduction diet within the past year?
    ____

12. How many times each year do you go on a weight reduction diet?
    ____

13. How long does the diet usually last? (select one)

    1. less than one month
    2. 1-3 months
    3. 4-6 months
    4. more than 6 months

14. Have you ever been on a diet to try to gain weight? yes = 1;
    no = 2 ____

15. Have you tried to gain weight within the past year? ____
yes = 1; no = 2 If answer is No skip to question #17

16. If yes, was it recommended or decided on primarily by (select one):

1. Physician
2. Family members (other than husband)
3. Self
4. Friend(s)
5. Husband
6. Media

17. Are you presently trying to _____ weight?
gain = 1; lose = 2; neither = 3

18. Are you dieting to lose weight? _____ yes = 1; no = 2

19. How much weight do you want to gain or lose (pounds)? _____

20. Do you think your weight is now:

Circle one: 1 = too heavy 2 = too light 3 = about right

21. Do you add salt to your food at the table?

1. almost never
2. sometimes
3. almost always but only after testing
4. almost always and before testing

22. Do you like very salty foods such as salted nuts, potato chips?
____ yes = 1; no = 2

23. Who does most of the grocery shopping in your family? (select one)

1. You
2. Your husband
3. You and your husband together
4. Whole family (if different than answer #3)
5. Other: specify _____

24. Who makes the majority of decisions about the groceries to buy?
(select one)

1. You
2. Your husband
3. You and your husband together
4. Whole family (if different than answer #3)
5. Other: specify _____

APPENDIX E

EXERCISE and ACTIVITY LEVEL

Below is a list of exercises and activities. Each question has 3 parts. If you participate in the activity or exercise on a weekly basis, please complete all 3 parts. If you do not participate in the activity, please leave blank.

Terms defined: Light-- no sweating; Mild-- limited sweating; Moderate-- sweating within 5 minutes; Vigorous-- profuse sweating

1. Baseball and/or softball
   A. Days/week 1___2___3___4___5___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How Long?_____

2. Basketball
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How long?_____

3. Bowling
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How long?_____

4. Calisthenics
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How long?_____

5. Canoeing
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How long?_____

6. Dancing (square, clogging, ballroom, modern)
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How long?_____

7. Chopping wood
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How long?_____

8. Gardening
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How long?_____

9. Golfing
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous ___
   C. How long?_____

10. Racquetball
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How long?_____

11. Cross country skiing
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How long?_____

12. Downhill skiing
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How long?_____

13. Soccer
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous ___
   C. How long?_____

14. Sprinting
   A. Days/week 1___2___3___4___4___6___daily___
   B. What level of intensity: light___mild___
      moderate___vigorous___
   C. How long?_____

15. Rugby
    A. Days/week 1___2___3___4___4___6___daily___
    B. What level of intensity: light___mild___
       moderate___vigorous___
    C. How long?_____

16. Tennis
    A. Days/week 1___2___3___4___4___6___daily___
    B. What level of intensity: light___mild___
       moderate___vigorous___
    C. How long?_____

17. Volleyball
    A. Days/week 1___2___3___4___4___6___daily___
    B. What level of intensity: light___mild___
       moderate___vigorous___
    C. How long?_____

18. Weight lifting
    A. Days/week 1___2___3___4___4___6___daily___
    B. What level of intensity: light___mild___
       moderate___vigorous___
    C. How long?_____

19. Recreational biking
    A. Days/week 1___2___3___4___4___6___daily___
    B. What level of intensity: light___mild___
       moderate___vigorous___
    C. How long?_____

20. Other_____
    A. Days/week 1___2___3___4___4___6___daily___
    B. What level of intensity: light___mild___
       moderate___vigorous___
    C. How long?_____

Part II.: Please answer the following questions.

1. What is your main form of transportation?

   Car_____
   Bike_____
   Walk_____
   Other_____ Explain _____

   What is the distance you walk/bike per day?

   less than 1 mile _____
   1-2 miles _____
   2-3 miles _____
   greater than 3 miles _____

2. Do you hike? no_____ yes_____

3. If yes, how many times per month_____
ON the average, what is the distance covered? _____

3. Do you run? no_____ yes_____

Types: Cross Country_____
days/week_____
miles run_____
how long_____
Field House or Track_____
days/week_____
miles run_____
how long_____
Graded surface_____
days/week_____
miles/week_____
how long_____

4. Do you swim? no____ yes____
Types: Recreational_____
days/week_____
miles/week_____
how long_____
Team swim_____
days week_____
miles/week_____
how long_____

Part III: Please answer the following questions:

1. Do you plan to change your exercise/activity level(s) due to being pregnant?

yes_____ no_____ unsure_____

2. If the answer to question #1 was "yes", please explain what changes you anticipate making:

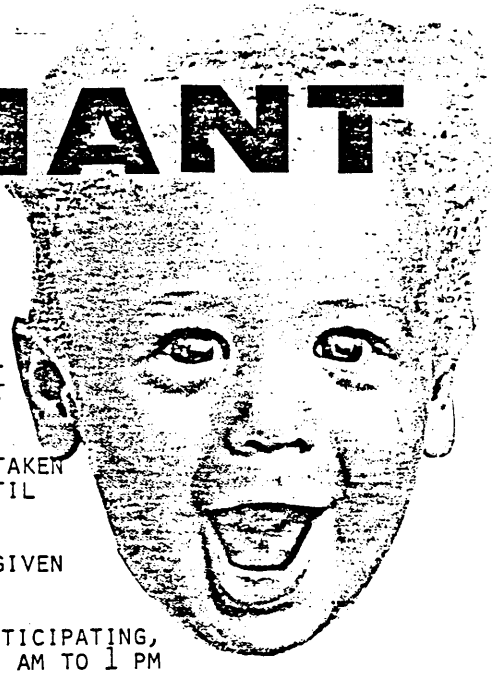
APPENDIX F

FOOD KNOWLEDGE and BELIEFS

		Agree	Disagree	Don't Know
1.	The diet of a woman before and during pregnancy can affect how healthy her baby will be.	_____	_____	_____
2.	Snacks can be an important part of your nutrient intake.	_____	_____	_____
3.	A pregnant woman needs to increase her intake of certain vitamins, minerals, and calories.	_____	_____	_____
4.	The way a food is prepared can change the amount of nutrients contributed to the diet.	_____	_____	_____
5.	Anemia can be prevented by eating foods high in calcium.	_____	_____	_____
6.	The "Basic Four" refers to the four things to do if your child is sick.	_____	_____	_____
7.	A fat baby is a healthy baby.	_____	_____	_____
8.	A fat child is at risk of becoming a fat adult more so than a slim child.	_____	_____	_____
9.	When a baby cries it is usually hungry.	_____	_____	_____
10.	Solid foods should be introduced as early as possible to an infant.	_____	_____	_____
11.	Cow's milk should not be given to an infant before 4 months of age.	_____	_____	_____
12.	Commercially prepared baby foods contain added salt and sugar.	_____	_____	_____

APPENDIX G

PREGNANT ?



THE DEPARTMENT OF HUMAN NUTRITION AND FOODS AT VIRGINIA TECH IS PLANNING A STUDY USING HEALTHY PREGNANT WOMEN.

SEVERAL BODY MEASUREMENTS WILL BE TAKEN FROM THE 16TH WEEK OF PREGNANCY UNTIL SIX MONTHS FOLLOWING DELIVERY.

MONETARY COMPENSATION WILL BE GIVEN FOR PARTICIPATION.

IF YOU ARE INTERESTED IN PARTICIPATING, PLEASE PHONE 961 5987 FROM 9 AM TO 1 PM AND ASK FOR DIANE DOWNING OR MARY DELATORRE.

APPENDIX H

WRITTEN EXPLANATION OF STUDY FOR POTENTIAL PARTICIPANTS

If you are pregnant your doctor has probably talked to you about weight gain during pregnancy. Current research has raised the question about what is "optimal" weight gain during pregnancy and whether this "optimal" or "normal" weight gain might be influenced by the woman's pre-pregnant body weight and body build. Some researchers have shown that underweight women entering pregnancy may need to gain more than the recommended amount of 24-28 lbs. while the overweight women entering pregnancy may not need to gain as much. The woman's body builds up fat during the second half of pregnancy to support the rapid growth of the baby during this time. Measures of skinfold thickness, as well as height and weight, have been widely used in an attempt to assess body fat changes during pregnancy.

The purposes of this study are to: 1) assess changes in skinfold measurements and weight throughout pregnancy and for a six month period following delivery; 2) in retrospect, relate changes in skinfold fat to weight gain during gestation and weight loss following delivery; 3) relate changes in skinfold thickness and weight to dietary intake information collected throughout the period via 72 hour food records; and 4) plot urinary pH, glucose, protein, and ketone excretion over the course of pregnancy and relate this to food intake and skinfold thickness changes.

Much research needs to be done to help the medical community do everything possible to insure the mother's and baby's health both during and following pregnancy. Your participation may help to provide a missing link. If you have any questions or concerns please let us know.

APPENDIX I

CONSENT OF PARTICIPATION FORM

Optimal maternal weight gain during pregnancy appears to be a very individualized phenomenon. The majority of weight gained in a normal pregnancy is the result of physiological changes that are designed to foster fetal and maternal growth. Much of the weight gain can be accounted for by the products of gestation. Research has shown that maternal weight prior to pregnancy may have an effect on maternal weight during pregnancy. Most of the weight gain attributable to the developing fetus occurs during the second half of pregnancy, when the fetus is growing at a very rapid rate. However, the maternal stores increase in quantity most rapidly before the middle of pregnancy and seem to stop enlarging before term. Measures of skinfold thickness, as well as height-for-weight, have been widely used in an attempt to assess body fat changes during pregnancy.

The purposes of this study are to:

(1) assess changes in skinfold measurements and body weight throughout pregnancy and for a 6 month period following delivery,

(2) in retrospect, relate changes in skinfold fat to weight gain during gestation and weight loss following delivery,

(3) relate changes in skinfold thickness and weight to dietary intake information collected throughout the period via 72 hour food records, and

(4) plot urinary pH, glucose, protein, and ketone excretion over the course of pregnancy and relate this to food intake and skinfold thickness changes.

I have received an explanation of the Nutrition Study to be conducted at Virginia Tech in the Department of Human Nutrition and Foods. The project will be directed by Dr. Janette Taper, faculty member, in the Department of Human Nutrition and Foods.

I understand that I will be asked to answer questions about socioeconomic background (education, occupation, etc.), food habits, over-all health, and lifestyle (exercise, etc.). I understand that I will be asked to come to the Virginia Tech campus for skinfold thickness and weight measurements during weeks 12, 16, 20, 24, 28, 32, 36, 40 of gestation and at monthly intervals for the first six months following delivery. I will also be asked to give a urine sample for measurements of urinary glucose, protein, pH, and ketones each time I come in.

The potential risks of this study (such as stress during the interview and tests) have been explained to me. I understand that I will receive $75.00 for being a subject in the study, payable at the end of my participation.

I understand that I am free to withdraw from the study at any time. I understand that all information will be considered private, will be treated in a confidential manner, and will not be revealed so as to cause embarassment. Dr. Taper or one of the other members of the research staff will be free to answer any questions I may have regarding this study.

Understanding the above, I agree to participate in the Nutrition Study to be conducted at Virginia Tech.

_____
Signature of Subject

_____
Social Security Number

_____ _____
Date Signature of Interviewer

Principal Investigator: Dr. L. J. Taper (961-5549)

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