THE UNIVERSITY OF ALBERTA

INFLUENCE OF MATERNAL WEIGHT CHANGES DURING PREGNANCY AND FOUR MONTHS POSTPARTUM ON LACTATION AND INFANT GROWTH: A COMPARISON WITH FORMULA FEEDING.

by

DOREEN AUDREY WALKER

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for the acceptance, a thesis entitled **INFLUENCE OF MATERNAL WEIGHT CHANGES DURING PREGNANCY AND FOUR MONTHS POSTPARTUM ON LACTATION AND INFANT GROWTH: A COMPARISON WITH FORMULA FEEDING** submitted by **DOREEN AUDREY WALKER** in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **NUTRITION**.

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ABSTRACT

Lactational outcome is believed to be positively influenced by adequate weight gain during pregnancy and by controlled weight loss or weight maintenance during the early postpartum period. To examine this notion, 257 primiparous mothers and their full-term singleton infants were studied during the first four postpartum months. Mothers ranged in age from 20 to 35 years; 141 infants were exclusively breast-fed whereas 116 infants were exclusively formula-fed; no infants received solids before two months of age.

Maternal characteristics for breast-feeding and formula-feeding groups were very similar for height, prepregnancy weight and pregnancy weight gain. Breast-feeding mothers were slightly older, and the difference was statistically significant (mean age 26.9 vs. 25.7 yrs, $p<0.05$). Thirty two percent of mothers reported smoking during pregnancy or within four months postpartum but less than one third of smoking women breast-fed their infants.

Mean infant birth weight was 3.4 kg (7.4 lb) for males and 3.3 kg (7.2 lb) for females. Infant weight at birth was positively correlated with maternal pregravid weight ($r=0.28$), length of gestation ($r=0.27$), pregnancy weight gain ($r=0.24$) and maternal age ($r=0.10$). For infants born to smoking mothers, birth weight and head circumference were reduced, but statistical significance was attained only when comparing infants of smoking mothers with male infants from the non-smoking group. Gestational age was not affected by smoking.

In general, rate of growth in length and weight was slower in breast-fed compared with formula-fed infants and in females compared

with males. Solid foods were first fed to breast-fed infants at a mean age of 3.6 months and to formula-fed males and females at 3.2 and 3.0 months, respectively. Whether solids were started at two, three or four months of age, no differences in rate of infant growth were observed. In each of three groups of infants classified by their birth weight as small, average or large in size, rate of growth in length, weight and head circumference during the first four months of life was very similar; mean weight gain was the same (3.6 kg) from birth to four months for the smallest (n=12) and largest (n=13) infants.

For maternal weight changes postpartum, no significant differences were found between breast-feeding and formula-feeding or between smoking and non-smoking mothers. Most mothers lost weight postpartum, but none of the groups had returned to their former pregravid weights by four months. To assess the effects of maternal postpartum weight changes on infant growth, breast-fed infants and their mothers were compared in several ways. Infants were first divided into groups by sex and then by deciles of weight gain from birth to two months and from two to four months for comparison with corresponding maternal weight loss. Similarly, mothers were divided into groups by deciles of weight loss postpartum for the same two month periods and compared with corresponding infant weight gain. Male and female infants were divided into groups according to whether their mothers gained, lost or maintained weight postpartum. Maternal weight loss was expressed as a percentage of pregravid metabolic weight [weight $(kg)^{0.75}$] and correlated with infant growth from birth to four months. No significant correlations between infant and maternal weight changes

were found with any of these comparisons. A stepwise multiple regression procedure was also used to relate infant weight gain during the first four months of life with maternal weight gain during pregnancy, pregravid metabolic weight, maternal height, length of gestation, maternal age and infant weight at birth. Infant weight gain was related only with maternal age ($r=-0.16$, $p=0.03$). Thus, in the present study, maternal weight changes during pregnancy and four months postpartum did not affect lactational outcome measured as infant growth.

THESIS ORGANIZATION

Chapter 1 presents a review of the current literature that describes the various effects of maternal and infant factors on lactational outcome. Maternal anthropometric parameters, ethnic, social, cultural, nutritional, physiologic, geographic and demographic factors that influence infant birth weight and growth are presented. Weight gain and physiologic adaptations during pregnancy as well as infant size and body composition at birth are discussed, and current infant feeding recommendations and studies describing patterns of early infant growth are included. Specific factors affecting lactational performance via breast milk production including hormones, withdrawal of milk from the breasts, mode of delivery, individual differences of mothers, frequency and duration of feeds, diet, postpartum weight changes, maternal energy expenditure and smoking are reviewed. Compositions of currently available infant formulas are compared with mature breast milk, and reasons for mothers choosing to breast-feed or formula-feed their infants are explored.

Chapter 2 reports the methodology and results of research conducted in Calgary during 1986 and 1987 which examined the influence of maternal weight changes during pregnancy and four months postpartum on lactational outcome. During the first four months of life, infant growth - particularly infant weight gain - represents an index of lactational performance. Since infant birth weight affects subsequent growth during infancy, and since external factors such as smoking may affect infant birth weight, these factors play an integral part in the analysis of lactational outcome.

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LITERATURE REVIEW AND RATIONALE

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I. INTRODUCTION

Weight gain during pregnancy is required for optimal growth of the fetus and preparation of the mother for lactation. Appropriate weight gain is assessed according to maternal prepregnant weight and stature, so that obese women are advised to gain less and very thin women to gain more than the 10 to 13 kg usually recommended. Infant birth size is a consequence of maternal pregravid weight, stature, pregnancy weight gain, length of gestation, nutritional status and lifestyle. Infant growth during the first few months of life is affected by birth size, feeding pattern and for breast-fed infants, adequacy of milk supply. This review examines the relationships between maternal factors, birth size and infant growth during the first four months of life for breast-fed and formula-fed infants.

II. MATERNAL FACTORS INFLUENCING BIRTH SIZE

Birth size is an important indicator of infant health (Schell & Hodges, 1985) that may affect infant feeding patterns (Churella et al. 1985) and early growth (Bhatia et al. 1983). Low-birth-weight babies, identified as those weighing 2500 g or less (Hytten & Chamberlain, 1980), very-low-birth-weight babies weighing 1500 g or less (Tyson et al. 1983), infants who have not attained normal intrauterine growth and development (Creasy & Resnik, 1984a) and oversized infants weighing 4500 g or more at birth (Khwaja et al. 1986) are at increased risk for morbidity and mortality. Low-birth-weight infants are more often fed formula than breast milk (Forman et al. 1985; Walker et al. 1987) and small for gestational age babies may not experience catch-up growth for long periods of time (Bhatia et al. 1983). Consequently maternal factors influencing size at birth are important as they affect infant health, growth, and feeding patterns.

Prepregnancy Body Size and Composition: Maternal height and pregravid weight are important determinants of infant birth size. Infant length (Lauber & Reinhardt, 1979; Schell & Hodges, 1985) and arm circumference (Lauber & Reinhardt, 1979) are correlated with maternal height and weight, while birth weight is strongly and independently associated with maternal pregravid weight (Garn & Pesick, 1982) apart from height, race, age, pregnancy weight gain, and smoking (Dimperio & Mahan, 1985). Although maternal pregravid weight independently affects birth weight, pregnancy weight gain exerts a further independent influence. Taken in combination, their effects on birth weight are additive. Thus high prepregnant weight and weight gain frequently produce the largest babies, and conversely, thin mothers with low pregnancy weight gain produce the smallest infants (Worthington-Roberts, 1985).

Hytten and Chamberlain (1980) reported that in Aberdeen women, babies born to the tallest and heaviest mothers (180 cm; 80 kg) averaged nearly 1000 g more in birth weight at term than babies of the shortest and lightest mothers (145 cm; 35 kg). Women who are underweight at time of conception usually deliver infants that weigh less than 3,000 g (Rosso, 1985) and the incidence of these women bearing low-birth-weight infants is twice that of women who are of normal weight at time of conception (Dimperio & Mahan, 1985). Supplementation of calories to underweight and undernourished mothers during pregnancy has been shown to increase birth weight (Picone et al. 1982b; Coward et al. 1984; Metcoff et al. 1985). Therefore, women who are underweight at time of conception are encouraged to gain more weight during pregnancy than women who are average or above average in weight (Dimperio & Mahan, 1985).

To predict infant birth size, a variety of formulas utilizing prepregnancy size have been used including the Weight for Height Ratio Index, [weight (kg)] x $[\text{height(cm)}^2]^{-1}$ x 100 (Bhatia et al. 1983), and Ponderal Index, [weight (kg)] x $[\text{height (m)}^2]^{-1}$ (Van Der Spuy, 1985). The prevalence of infants with birth weights below the tenth percentile has been shown to double when maternal Ponderal Index is below 19.1 (Van der Spuy, 1985) which is equivalent to a Weight Height Ratio Index of 0.191. Dimperio and Mahan (1985) believe that maternal weight-for-height provides a more accurate index than absolute weight, whereas Garn and Pesick (1982) believe that maternal pregravid weight alone best predicts birth size. Micozzi et al. (1986) determined correlations of various body mass indices with stature and weight, using anthropometric data from more than 14,000 subjects collected for the U.S. National Health and Nutrition Surveys, NHANES I (1971-1974) and NHANES II (1976-1980). In the population studied, the most useful body mass indices for women were [weight (kg)] x $[\text{stature (cm)}]^{-1}$ and [weight (kg)] x $[\text{stature (cm)}^{1.5}]^{-1}$. For men, the most useful body mass index was [weight (kg) x $[\text{stature (cm)}^2]^{-1}$ (Micozzi et al. 1986) which is currently the index commonly recommended for use in Canada

(Health & Welfare, 1988). These body mass indices reflect body fatness and are independent of stature and highly correlated with weight (Micozzi et al. 1986). Even though the indices detailed by Micozzi et al. (1986) were derived for the general population, the two recommended for application to women may also be useful in relation to pregnant women, since a high correlation of the indices with weight was maintained at extremes of fatness and leanness. Whatever the approach, maternal prepregnancy body size clearly influences infant size at birth.

Weight Gain During Pregnancy: Pregnancy weight gain is positively correlated with infant birth weight, independent of race, age, pregravid weight and smoking. The average primigravida, eating to appetite, will gain about 12.5 kg (27.5 lb.) although the range may vary from weight loss to weight gain of 23 kg or more (Hytten & Chamberlain, 1980). Higher weight gain during pregnancy is associated with higher birth weights and improved postnatal growth (Dimperio & Mahan, 1985) whereas low weight gain of 6.8 kg (15 lbs.) or less may result in shorter gestations (reduced 0.5 wk.), smaller placentas, lower birth weights, ponderal indices, and slower postnatal growth although birth length may not be affected (Picone et al. 1982b) unless food deprivation is extreme. This was the case for infants born in Holland during the winter of 1944-45, known as the "hunger winter" when food supplies were cut off during the Second World War, with the consequence that both infant birth weight and length were significantly reduced (Smith, 1947). Low weight gain, particularly in underweight women, has been associated with an increased incidence of low birth weight (Worthington-Roberts, 1985) whereas higher gains and pregnancies with edema have reduced incidence of low birth weight. Women who gain little weight and have smaller babies may reflect an overall pattern of poor reproduction rather than a causal relationship (Hytten & Chamberlain, 1980).

Demographic Factors: Birth size, in particular birth weight, may be affected by factors such as parents' education (Shiono et al. 1986a; Behrman, 1985), time of initiation of prenatal care (Behrman, 1985), marital status, socioeconomic status and alcohol consumption (Shiono et al. 1986a). Prevalence of low birth weight is lower among women with at least 12 years of education and among women who initiate prenatal care during the first three months of pregnancy (Behrman, 1985). Prenatal growth retardation in infants born to disadvantaged women may be caused by undernutrition (Worthington-Roberts et al. 1985).

Parity: Primiparous women tend to bear smaller babies than women who have previously had one child, with the difference in birth weight at term averaging about 100 g. Additional increases in birth weight for other siblings are unlikely, although there may be a slight increase in weight when comparing third- with second-born children (Hytten & Chamberlain, 1980).

Age: Within the childbearing years, birth weight is inversely related to age. Prevalence of low birth weight is greatest among teenagers under age 15; however, it diminishes with advancing teenage years and attains its lowest level between ages 25 and 29. Thereafter, low birth weight prevalence again increases slowly with advancing maternal age (Behrman, 1985).

Ethnicity: Birth weight varies considerably between ethnic groups. Variation likely reflects differences in maternal size, nutrition and disease, but whether ethnic origin exerts an additional genetic influence is not clear. Nevertheless, African, Chinese, and Indian women tend to have smaller babies than European women of the same size (Hytten & Chamberlain, 1980), and Blacks have babies of lower average birth weight than Whites, even after adjustments for negative environmental factors (Rosso, 1985). A study by Shiono et al. (1986a) examining more than 29,000 pregnancy outcomes in northern California found large differences in birth weight among babies of different ethnic groups. White infants had the highest birth weight with a mean weight of 3.48 kg. Birth weights for Hispanics, Asians and Blacks were lower than for Whites by an average of 72, 167, and 183 g respectively, after controlling for other variables such as smoking, alcohol, maternal weight-for-height, and gestational age. Baker (1986) observed that babies born to Asian (primarily Pakistani) mothers living in England were on average 173 g lighter at birth than their Caucasian counterparts.

Length of Gestation: Gestational age is the most significant variable determining size at birth. Gestational age directly affects weight and indirectly affects length (Schell & Hodges, 1985). Fetal weight increases from approximately 300 g at week 20 to 1500 g at week 30 and to 3400 g at week 40. For the purpose of comparing birth weight and other developmental indices, infants are grouped according to completed weeks of gestation as "pre-term" (less than 37 weeks), "term" (37 to 41 weeks) and "post-term" (more than 41 weeks) (Hytten & Chamberlain, 1980). Growth retardation in utero may affect birth size irrespective of gestational age.

Altitude: An inverse relationship between altitude and birth weight has been reported in the United States. Yip (1987) analyzed more than 12 million records of infants born from 1978 to 1981 and stratified groups according to 500 m gradations for altitude of the mother's resident county. Analysis of a selected "optimal" subpopulation of white births which controlled maternal age, parental education, marital status and gestational age showed that mean birth weight was reduced by 351 grams for infants whose mothers lived at altitudes greater than 2500 metres compared with controls at sea level. Compared with controls, prevalence of low birth weight more than doubled at high altitude. This effect was primarily related to an increased incidence of intrauterine growth retardation, thought to be due to hypoxia.

Smoking: Birth weight (Hytten & Chamberlain, 1980; Picone et al. 1982a; Grigsby Harrison et al. 1983; Schell & Hodges, 1985; Spady et al. 1986), length (Grigsby Harrison et al. 1983; Schell & Hodges, 1985), head circumference (Grigsby Harrison et al. 1983; Spady et al. 1986), arm circumference (Grigsby Harrison et al. 1983) and lean body mass (Spady et al. 1986) are reduced in infants born to mothers who smoke. Birth weight is more strongly affected by maternal smoking than are other anthropometric parameters, and the reduction in birth weight is inversely proportional to the amount smoked (Schell & Hodges, 1985). Behrman (1985) suggested that smoking may double the risk of low birth weight and that smoking is a contributing factor in 20-40% of low birth weight cases in Canadian and American infants.

Reduction in birth length appears to be related to decreased birth weight (Schell & Hodges, 1985) but may only be apparent at the highest dose level of smoking (Grigsby Harrison et al. 1983). Spady et al. (1986) determined lean body mass in newborns by measuring total body potassium, and found that while average lean body mass was reduced by 289 g in infants of smoking mothers, fat was reduced by only 6 g and skinfold measurements were not significantly altered. Shiono et al. (1986b) determined that smoking also increased the probability of preterm birth and that this effect was dose-related as well. Four percent of preterm (<37 weeks' gestation) and 9% of very preterm births (<33 weeks gestation) were related to smoking one or more packs per day.

Several mechanisms to explain the complex effect of smoking on birth size have been suggested. Low pre-pregnancy weight and pregnancy weight gain have been reported in some studies (Picone et al. 1982a; Grigsby Harrison et al. 1983) but not in others (Spady et al. 1986). At one time, it was believed that reduced pregnancy weight gain observed in smoking mothers was due to reduced energy intake. On the contrary, smoking mothers have been shown to consume more food energy than non-smokers, but maternal energy utilization may be reduced (Picone et al. 1982a; Grigsby Harrison et al. 1983) and heart rate, blood pressure, basal metabolic rate and lipolysis may be increased, thereby raising caloric requirements. Maternal obesity apparently eliminates the effects of smoking on birth weight (Picone et al 1982a). A high proportion of women who smoke have other characteristics which make them more prone to delivering small babies, since smokers tend to be teenagers, single women or those living common-law, women with no post-secondary education (Stewart & Dunkley, 1985) and those who drink alcohol (Schell & Hodges, 1985). Folic acid deficiency in smoking mothers has also been implicated (Spady et al. 1986). Smoking may result in diminished placental perfusion (Picone et al. 1982a,b) and oxygen availability (Picone et al. 1982a; Grigsby Harrison et al. 1983) thereby reducing fetal growth, particularly growth of lean tissue. The observation that well-nourished infants at high altitude have more fat and less lean tissue than comparable infants at low altitude supports the theory that reduced oxygen availability influences lean tissue growth (Grigsby Harrison et al. 1983). Smoking has also been associated with premature rupture of membranes and other placental complications such as placenta previa and abruptio placenta (Shiono et al., 1986b). Whatever the cause, it is clear that smoking dramatically reduces infant birth size.

Diet: Diet before and during pregnancy is positively correlated with birth weight (Dimperio & Mahan, 1985) and pregnancy outcome. Generally, although requirements for most nutrients are increased during pregnancy (Duhring, 1984) emphasis is placed on higher caloric requirements since caloric adequacy is an index of other nutrient intake (Dimperio & Mahan, 1985). Women are cautioned not to use pregnancy as an excuse to consume an abundance of high calorie-nutrient-poor foods but rather to choose quality foods (Worthington-Roberts et al., 1985) to provide an extra 100 kilocalories and 15 grams of protein per day during the first trimester and 300 kilocalories and 20 to 25 grams of protein per day during the last two trimesters of pregnancy. Recommended intakes for iron, folacin, calcium and vitamin D are also increased during pregnancy (Canada, Health and Welfare, 1987). Although accurate information about requirements for many vitamin and minerals during human pregnancy is generally lacking, both embryonic development and growth of the fetus may be compromised by specific nutrient deficiencies and excesses, as reviewed by Worthington-Roberts et al. (1985).

Alcohol: A moderate intake of alcohol during pregnancy does not appear to adversely affect birth weight (Lumley et al. 1985) or length of gestation (Shiono et al. 1986b), but maternal consumption of two or more glasses per day has been shown to reduce birth weight by an average of 300 g (Lumley et al. 1985). Few women would be considered heavy drinkers during pregnancy; Shiono et al. (1986b) determined that only 2.9% of over 30,000 women in northern California consumed one or more drinks per day during their first trimester of pregnancy. However, women who were heavy drinkers also tended to smoke, compounding the adverse effects. Worthington-Roberts et al. (1985) emphasized that no safe level of maternal alcohol consumption has been established, and studies vary widely in their definitions of "moderate" drinking. "Fetal alcohol effects" may be observed as a result of moderate alcohol ingestion, exhibited by a higher incidence of abruptio placentae, spontaneous abortion and low birth weight. "Fetal alcohol syndrome", usually associated with heavy maternal drinking, may present with the classic features of facial dysmorphology, prenatal and antenatal growth deficits and mental retardation. The adverse affects on pregnancy outcome resulting from maternal alcohol consumption are believed to be dose-related.

Caffeine: Consumption of caffeine from coffee, tea, colas and drugs has been shown to reduce birth weight. Martin and Bracken (1987) found that women who consume 151-300 mg of caffeine per day (equivalent to 2-3 cups of coffee) have a twofold risk of having a low birth weight infant compared with women who consume no caffeine. Similarly, women who consume more than 300 mg of caffeine per day (greater than 3 cups of coffee) have a fourfold risk. In term babies, significant reductions in birth weight equal to 105 grams were observed with maternal caffeine consumption greater than 300 mg per day. It was suggested that caffeine, not other dietary constituents, was responsible for growth retardation of the fetus delivered after 36 weeks gestation.

Maternal Drug Dependency: Significant reductions in birth weight have been observed in infants born to opiate-dependent mothers. In a recent New York study of 150 drug-dependent mother-infant pairs, Doberczak et al. (1987) determined that perinatal exposure to drugs such as cocaine, diazepam, heroin, barbiturates, amphetamines and amitryptaline resulted in a fivefold increase of intrauterine growth retardation compared to drug-free control subjects of similar racial background and socio-economic status. Twenty percent of infants born to drug-dependent mothers exhibited growth retardation, and mean birth weight of the study group was at the 25th percentile for gestational age. Clearly, the reduction in birth weight was caused by abnormal fetal growth related to narcotic-mediated reduction in fetal cell number.

III. PREGNANCY WEIGHT GAIN: Composition and Recommendations

Composition: Weight gain during pregnancy represents accretion of fetal, placental and maternal tissues. A 12.5 kg (27.5 lb) gain will on average consist of 3400 g (7.5 lb) fetus, 650 g (1.3 lb) placenta, 800 g (1.75 lb) amniotic fluid, increases of 970 g (2.2 lb) in weight of the uterus, 400 g (0.8 lb) in the breasts, 1250 g (2.7 lb) in blood volume, 1680 g (3.7 lb) in extracellular fluid, and approximately 3.5 kg (7.7 lb) of fat. When generalized edema accompanies pregnancy, additional fluid and less maternal fat may comprise overall weight gain (Hytten & Chamberlain, 1980).

Recommendations: It is commonly recommended that optimal weight gain during pregnancy be determined according to the woman's pregravid weight (Dimperio & Mahan, 1985). A gain of approximately 10 to 13 kg (22-28 lb) is often quoted as desirable (Picone et al. 1982a; Duhring, 1984), of which 9 kg (a little less than 20 lb) should be acquired during the last half of pregnancy (Hytten & Chamberlain, 1980). Small and underweight women should gain more than 13.6 kg (30 lb) while moderately overweight women should gain 9-11.5 kg (20-25 lb) and obese women, 7-9 kg (15-20 lb). Weight reduction diets are not considered appropriate during pregnancy (Dimperio & Mahan, 1985). Rosso (1985) has developed a chart to monitor and individualize weight gain during pregnancy based on prepregnancy weight and height. For underweight women, maternal weight should increase during pregnancy to reach a 'critical body mass' equal to 120% of standard weight, while a smaller net gain is recommended for overweight women. The chart is useful for women with prepregnancy weight up to 130% of standard; for women who exceed this limit, a gain of at least 7 kg is recommended.

Although the metabolizable energy cost of pregnancy has been estimated at nearly 75,000 kcal, recommendations for total caloric increments have historically varied from 36,000 to 40,000 kcal per pregnancy (Hytten and Leitch, 1971). Current Canadian guidelines recommend a total increment of approximately 64,000 calories, obtained by the addition of 100 kcal/day during the first trimester and 300 kcal/day during the second and third trimesters of pregnancy (Canada. Department of National Health & Welfare, 1987). Several studies indicate that actual energy intake is much lower (Baird et al. 1985; Durnin et al. 1985), representing less than 20,000 kcal overall. The average daily caloric intake during pregnancy is increased by only 75 kcal (Durnin et al. 1985) to a total of approximately 2,000 (Picone et al. 1982a; Duhring, 1984) to 2100 kcal/day (Durnin et al. 1985). It is well documented that many women eat considerably less than is recommended, yet they nevertheless gain weight and produce a normal baby (Baird et al. 1985). Durnin (1987a) has suggested that reductions in energy expenditure may account for much of the difference between estimated and actual energy costs of pregnancy, and that increases in basal metabolic rate and amount of fat deposited during pregnancy are less than was previously reported (1987b). Thus, the energy cost of pregnancy is now believed to be about 60,000 kcal. Current recommendations for caloric increments are therefore too high (Durnin, 1987c). The real requirements appear to be about 50-110 kcal/day for the first 34-36 weeks and 200-300 kcal/day for the last few weeks until term (Durnin et al. 1985).

IV. PHYSIOLOGIC ADAPTATIONS OF PREGNANCY

During pregnancy, metabolic adaptations occur to safeguard both the mother and fetus against variable and restricted energy intake in order to ensure satisfactory growth and development of the fetus and to provide energy stores for pregnancy and lactation. These adaptations are achieved by a reduction in maternal energy expenditure through decreased physical activity and increased metabolic efficiency and also by two metabolic phases of pregnancy believed to be regulated by placental steroid balance. The first phase occurs during the first half of pregnancy and is characterized by deposition of maternal fat stores (Baird et al. 1985) averaging 3.5 kg. (Hytten & Chamberlain, 1980). Progesterone, which dominates this phase, is believed to be responsible, via insulin, for conserving energy and facilitating deposition of fat stores. The second phase, during the second half of pregnancy, is a period of rapid fetal growth. Estrogens are believed to mediate the redirection of available energy to the fetus by facilitating the transfer of lipid and glucose from the circulation to meet fetal requirements (Baird et al. 1985). In addition, appetite increases for most women during pregnancy, possibly caused by progesterone, and in early pregnancy, by falling levels of plasma glucose and amino acids (Hytten & Chamberlain, 1980). Thus adaptations during pregnancy promote both growth and development of the fetus and health of the mother, even when nutritional conditions may not be optimal.

V. SIZE AND BODY COMPOSITION OF THE NEWBORN

In 1979, new percentile curves were published for infant weight, length, and head circumference based on United States National Center for Health Statistics data. Accurate measurements made on large, nationally representative samples of children during the period from 1963 to 1975 were used to develop these curves (Hamill et al. 1979) which are now widely used as standards (Rowland, 1985) for assessing physical growth of children. Comparisons with these standards facilitate assessment of size, nutritional status and growth of children in the U.S.A. and around the world. Normal growth is indicated by measurements falling between the 25^{th} and 75^{th} percentiles (Hamill et al. 1979).

Body composition of the newborn is of interest due to the relationship between size at birth and postnatal growth. Fomon (1974) and Ziegler et al. (1976) have devised a 'reference fetus' detailing body composition at various gestational ages. An immature fetus or very low birth weight infant has a high proportion of water and little adipose tissue (Walker & Watkins, 1985). Subcutaneous fat deposition in the fetus begins at about 28 weeks (Grigsby Harrison et al. 1983) and continues to increase, along with protein, while the concentration of water decreases with advancing gestational age (Ziegler et al. 1976). Although reported values vary (Widdowson, 1974; Ziegler et al. 1976), an infant weighing 1.2 kg has approximately 42 g (3.5%) fat whereas infants weighing 2.2 and 3.5 kg contain 165 (7.5%) and 560 g (16%) fat, respectively (Widdowson, 1974). Changes in fetal body composition may occur within short time intervals of a week or less. The major constituents of the reference fetus at term, showing changing body composition, (Ziegler et al. 1976) are listed (Table 1-1).

Percentage body fat in full term infants may vary considerably at birth, ranging from 11-28% (Widdowson, 1974). Female infants tend to be slightly fatter than male infants (Fomon et al. 1982) (Table 1-2). After birth, body fat continues to increase until it peaks between four and six months of age (Walker & Watkins, 1985).

Table 1-1 Body Weight, Water, Protein and Lipid Composition of the Reference Fetus at 38-40 Weeks Gestation

Gestational Age (wk)	Body Weight (g)	Water* (g)	Protein* (g)	Lipid* (g)
38	3160	75.6	11.8	9.9
39	3330	74.8	11.9	10.5
40	3450	74.0	12.0	11.2

* Per 100 g of body weight

Table 1-2 Comparison of Length, Weight, Protein and Fat Composition of Male and Female Infants at Birth

	Length (cm)	Weight (kg)	Protein (% body wt.)	Fat (%)
Males	51.6	3.5	12.9	13.7
Females	50.5	3.3	12.8	14.9

VI. INFANT FEEDING RECOMMENDATIONS

Breast-feeding is strongly recommended for all full-term newborns as the sole source of nutrients for the first three to six months of life, except in a few instances where contraindications preclude breast-feeding (Nutrition Committee, Canadian Paediatric Society, 1978). Ideally breast-feeding is continued for most infants throughout the first six to nine months. However, commercially prepared formula is considered the most acceptable substitute for breast-milk during the first six months of life, after which time whole cow's milk may be introduced (Nutrition Committee, Canadian Paediatric Society, 1979).

Solid foods are recommended for introduction to infants at about four to six months of age, a time deemed appropriate according to neuromuscular development, physiological maturity and nutritional requirements (Committee on Nutrition, American Academy of Pediatrics, 1980). The Nutrition Committee of the Canadian Paediatric Society (1979, 1980) states that solids should be started by six months of age to avoid nutritional deficits, but in infants who are unsatisfied with milk feedings as the sole source of nutrition, solids may be started at three or four months of age. Fomon et al. (1979) suggest that since introduction of solids before five months of age may interfere with establishment of sound eating habits and contribute to greater caloric intake and overfeeding, both breast-fed and formula-fed infants should first receive solids at five to six months of age.

VII. INFANT GROWTH DURING THE FIRST SIX MONTHS OF LIFE

Early infant growth is determined by gestational age, birth weight and feeding patterns. Length, weight, and head circumference may be compared to National Center for Health Statistics percentiles, comparisons which are useful for monitoring rate of growth and identifying infants who fall into extremes of the range, indicating risk of health or nutritional problems.

Formula-fed Infants: Formula-fed infants grow, on average, at a faster rate during the first few months of life than breast-fed infants. Differences are most apparent in terms of weight gain (Czajka-Narins & Jung, 1986), while length may (Fomon et al. 1982) or may not (Czajka-Narins & Jung, 1986) vary significantly according to feeding pattern.

Exclusively Breast-fed Infants: Breast-fed infants may grow at comparable rates (Ahn & Maclean, 1980) or slightly more slowly (Czajka-Narins & Jung, 1986) than formula-fed infants during the first six months of life. Ahn and MacLean (1980) determined that both weight and length of 96 breast-fed infants remained above the 50^{th} National Center for Health Statistics percentiles for at least the first six months, indicating adequate growth during that period. However, Ahn and MacLean (1980) noted that length and Czajka-Narins and Jung (1986) noted that weight was lower at six months of age in exclusively breast-fed male babies compared to reference male infants; thus recommendations regarding infant feeding may need to be tailored according to sex of the infant. Nevertheless, breast-fed babies are less likely than formula-fed babies to be overweight (Czajka-Narins and Jung, 1986). Whether growth rates of exclusively breast-fed infants are actually preferable to those of formula-fed infants has yet to be determined, since the prevalence of exclusive breast feeding to six months is low and therefore published information ususally relates to small numbers of infants.

Infants Small for Gestational Age: Infants born small for gestational age, defined as term babies with birth weight of 2500 grams or less, remain smaller on average throughout early childhood than babies born appropriate for gestational age (Bhatia et al. 1983; Bhargava et al. 1985) although some catch-up growth is possible, particularly during the first three months of life (Rowland, 1985).

Infants Born to Smoking Mothers: Infants born to smoking mothers commonly are lower in weight at birth and gain weight at a slower rate early in life than infants of non-smoking mothers. Differences in size have been shown to persist up to seven years of age (Grigsby Harrison et al. 1983).

Effects of Solids Introduction: Many infants are given solids at a much younger age than is commonly recommended (Fomon, 1975, Fomon et al. 1979; Myres, 1979; Yeung et al. 1981a; Canada, Health & Welfare, 1982; Quandt, 1984) which may be harmful, especially when solids are introduced at one to two months of age (Committee on Nutrition, American Academy of Pediatrics, 1980). Formula-fed infants generally receive solids earlier than breast-fed infants (Myres, 1979; Yeung et al. 1981a; Canada, Health & Welfare, 1982) since formula-feeding mothers tend to respond to impressions of unsatisfied hunger whereas breast-feeding mothers more often follow the advice of their own pediatricians or follow written guidelines (Ahn & Maclean, 1980).

Quandt (1984) studied the effects of solids introduction on the diet and growth of 45 exclusively breast-fed, first-born infants during the first six months of life. When solids were introduced to infants less than four months old, nursing frequency and rate of weight gain decreased although growth in length was unaffected. The reduction in weight gain, attributed to interference with lactation, is contrary to the suggestion by Fomon et al. (1979) that early introduction of solids results in overfeeding. Ferris et al. (1980) examined the effects of diet on growth of 92 female infants and found no differences in weight gain to age six months in either breast or formula-fed infants that were introduced to solids after two months of age. However, when solid foods were introduced earlier, formula-fed babies gained significantly more weight than breast-fed babies. Ferris and co-workers (1980) suggest that lactating mothers whose breast milk volume is inadequate may be permitted to introduce supplementary feedings early.

It appears that introduction of solids affects growth in varying ways in breast-fed and formula-fed infants. Early introduction of solids may reduce lactation and infant growth in breast-fed babies and increase overfeeding and overweight in formula-fed babies. Further investigation of large numbers of infants is required to determine specific cause and effect of solids introduction on infant feeding, growth, and in breast-feeding women, lactational outcome.

VIII. LACTATIONAL PERFORMANCE

It has been suggested that lactational performance is a dominant factor in determining infant growth (Prentice, 1985). The first two months postpartum are critical for establishing lactation (McNally et al. 1985) and many factors contribute to its success or failure (Yeung et al. 1981b). In 1985, 78% of mothers in Calgary initiated breast-feeding but only 40% persisted to four months (Walker et al. 1987). However, for women who do persist with breast-feeding for a reasonable length of time, satisfactory weight gain in their infants is considered an acceptable index of lactational performance (English, 1985).

During pregnancy, altered levels of several maternal hormones initiate changes in breast structure to prepare for lactation. Increased prolactin, in particular, is instrumental in the culmination of milk synthesis by converting presecretory epithelium into active cells. Estrogen, progesterone, placental lactogen, adrenal steroids, thyroid hormone, insulin and growth hormone are also important in the initiation of lactation. Oxytocin facilitates milk letdown through the breast and nipple to the infant; physical removal of milk by the infant stimulates further milk synthesis (Chappell & Clandinin, 1984) and the release of oxytocin and prolactin which are necessary for maintaining and augmenting lactation (Gil, 1985). The amount of prolactin released during suckling in the early puerperium correlates significantly with the amount of milk produced. Larger amounts of prolactin are released by 'good' feeders (more than 700 ml of milk per day) than by 'poor' feeders (less than 300 ml of milk per day).

However, when a breast pump is used to remove milk from both breasts, milk yield and amount of prolactin released increase, indicating that other factors such as inefficient removal of milk by the infant or by manual expression without a breast pump may affect prolactin secretion and lactational outcome (Hytten & Chamberlain, 1980). Thus factors which determine lactational outcome are complex; in particular, factors which affect maternal endocrine function may alter milk production and lactational performance (Chappell & Clandinin, 1984).

Mode of Delivery: Delivery by cesarean section imposes increased risk of morbidity and mortality for both mother and infant (Creasy & Resnick, 1984b). However, lactational outcome is similar following cesarean section or normal delivery since both the timing of milk "coming in" and the changes in milk composition for lactose, proteins, fat, electrolytes and glucose during the first seven days postpartum are similar for the two groups (Kulski et al. 1981).

Breast Milk Production: Approximately 750 kcal are required daily for milk production (Duhring, 1984). As one-third of this energy may be derived from maternal fat stores, adequate weight gain during pregnancy is important to assist lactation (Crawford et al. 1985). Energy in the form of glycerol is obtained from adipose tissue and from glucose, the carbohydrate precursor in the mammary gland (Garton, 1963). Adipose tissue also contributes to the fatty acid profile of breast milk (Hartmann et al. 1985), since stored triglycerides represent the largest pool of potentially available fatty acids in the body (Field et al. 1985). The remainder of energy required for milk production should be obtained from dietary additions, equaling about 450 (Canada, Health & Welfare 1986) to 500 kcal/day (Duhring, 1984).

Breast Milk Volume: Volume of breast milk produced largely determines lactational outcome (Jelliffe & Jelliffe, 1978) as lack or perceived lack of milk is frequently stated as a primary reason for early termination of breast-feeding (Yeung et al. 1981b; Goodine & Fried, 1984). Wide variations in breast milk output occur due to differences between individual mothers, stage of lactation (Prentice et al. 1981a), length of time between feedings (Prentice et al. 1981a; English, 1985), early introduction of formula supplements (Task Force, American Academy of Pediatrics, 1984) or solid foods (Tuckerman & Turco, 1983; Ferris & Jensen, 1984; Stuff et al. 1986), parity (Prentice, 1985), maternal age (Hytten & Chamberlain, 1980), diet, particularly energy intake (Butte et al. 1984), capacity of the breasts (English, 1985), and in under-developed countries, season of the year (Prentice et al. 1981b). Milk volumes are low for the first few days following parturition (Tuckerman & Turco, 1983), but once lactation is well established, the average milk output of exclusively breast-feeding, well-nourished mothers ranges from approximately 600 to 925 ml/24 hr (Ferris & Jensen, 1984) although milk volumes as high as 1100 ml/24 hr have been reported in Australia (Rattigan et al. 1981; Saint et al. 1984). Women breast-feeding twins or feeding their own singleton infants and expressing milk for other infants are able to produce more milk; yields of 1200-3300 ml/24 hr have been recorded (Hartmann et al. 1985). Frequent feeding, complete emptying of breasts at each feed and feeding on demand increase milk volumes, while partial breast-feeding and early introduction of solids decrease milk production.

Breast Milk Composition: Wide variability of breast milk composition appears to be responsible, in part, for differences in lactational outcome. Breast milk composition varies with length of gestation (Ferris & Jensen, 1984) stage of lactation (Hartmann et al. 1985; Lonnerdal, 1985), parity, body composition (Prentice, 1985), maternal nutritional status (Hartmann et al. 1985), diet (Pita et al. 1985; Coveney, 1985), drug use, physiology of the mammary glands, and contact with environmental pollutants (Coveney, 1985). Striking differences in breast milk composition are apparent between mothers, but individual mothers produce milk of characteristic quality during an entire lactational period (Prentice, 1985). Milk composition has been shown to change within a feed, within a day (Ferris & Jensen, 1984; Hartmann et al. 1985; Gillies & Neill, 1985), between days (Ferris & Jensen, 1984), during the menstrual cycle (Hartmann et al. 1985) and between different breasts of the same mother (Ferris & Jensen, 1984).

Colostrum is the secretion obtained from the mammary glands during the first few days following parturition (Gil, 1985). Protein and immunoglobulins are higher in colostrum than in transitional milk (6-10 days postpartum) or mature milk (day 11 postpartum and thereafter). As lactation advances, concentrations of sodium, potassium, zinc, iron, and protein decline, and composition of fat changes as medium chain fatty acids (C_{10}-C_{12}) increase and palmitic (C_{16}) and stearic (C_{18}) acids decline (Pita et al. 1985). Fatty acids are derived from two sources; from synthesis in the mammary gland and from serum lipids resulting from dietary intake and lipolysis of body tissues (Hartmann et al. 1985).

Fat is the most variable major component of breast milk. Although fat normally accounts for 50-60% of its calories (Jensen et al. 1985) the relative fat content of breast milk may range from 37 to 195% of the mean (Prentice, 1985), and the energy content from 446 to 1192 kcal/l (Tuckerman & Turco, 1983). Fat content varies significantly during a feed, between feeds, and with time of day (Prentice et al. 1981a). Milk lipids tend to be lower in undernourished (Hartmann et al. 1985) or thin women (Prentice et al. 1981a) and higher in women who are primiparous, under age 30, and in those who have a high proportion of body fat based on triceps skinfold measurements (Prentice, 1985). Breast milk fat concentration is highest (Prentice et al. 1981b) and most variable (Schell & Hodges, 1985) during the first three months of lactation; levels then decrease and stabilize within the first year (Prentice et al. 1981b). Reduced amounts of milk lipid which have been implicated in the early termination of breast-feeding (Ferris & Jensen, 1984) may result in the perception by some mothers that their milk is inadequate (Yeung et al. 1981b; Goodine & Fried, 1984).

Frequency and Duration of Feeds: Feeding on demand rather than following a rigid schedule appears to improve lactational capacity by influencing the release of key lactogenic hormones. However, withholding milk feedings during the night does not necessarily reduce milk output, as shown by Butte et al. (1985). Forty-five exclusively breast-fed infants were studied from birth to four months; infants who were breast-fed throughout a 24-hour day consumed the same amount of milk, on average, as those infants who were not fed between midnight and 6 a.m. Infants who did not feed during the night significantly increased their milk consumption during the day, and milk production was adapted to meet those conditions.

Maternal Diet: Women who restrict food intake while lactating have difficulty maintaining lactation (Ferris & Jensen, 1984) and energy intakes less than 1200 kcal/day have been associated with reduced milk output. However, successful lactation can be maintained over a wide range of dietary conditions (Coward et al. 1984) and a woman's dietary energy requirements are highly dependent on her body fat stores as well as her activity levels and metabolic needs (Butte et al. 1984). Energy utilization becomes more efficient when energy intakes are low, particularly during lactation (Coward et al. 1984). Schutz et al. (1980) determined that there were no significant differences in mean total energy intake (1929 $\pm$ 360 vs. 1875 $\pm$ 404 kcal/day) or expenditure (2007 $\pm$ 292 vs. 1966 $\pm$ 382 kcal/day) comparing lactating and non-lactating women in Guatemala. Thus, although lactating women did not increase their energy intake, they were able to successfully maintain lactation. However, these women were also losing weight rapidly, and skinfold tests indicated that adipose tissue was reduced. Roberts et al. (1985) studied lactational performance in baboons fed ad libitum and restricted diets, and found that efficiency of energy utilization increased by 17-25% when diets were restricted. At 80% restriction, animals were able to maintain milk output and protect body nutrient stores, but at 60% restriction, milk output was reduced and body stores rapidly mobilized. It appears quite clear that adequate dietary intake during lactation is critical for successful lactational outcome.

Supplementation: Nutritional supplementation of lactating African women in Keneba, The Gambia was conducted by Prentice et al. (1983) to determine the effects of dietary interventions on breast milk volume and quality in undernourished women. The supplement provided to 130 mothers increased maternal energy intake by approximately 700 kcal/day to a mean level of 2291 + 14 kcal/day. Although volume was unaffected, supplementation did improve milk composition since protein, fat, and vitamin concentrations increased. However, since milk lactose concentrations decreased, energy content did not change.

Energy expenditure: A study of lactating and virgin rats fed ad libitum and restricted diets showed that lactating animals used less energy on activity and maintenance than did control animals at each level of dietary energy consumption, including ad libitum intake. At 80% restriction, energy expenditure was reduced but milk production was maintained. However, when food was restricted to 60% of ad libitum, energy expenditure decreased to its lowest level, milk output was diminished, and growth of litters was retarded (Roberts & Coward, 1984). A similar study in lactating baboons produced the same results at levels of 60 and 80% dietary restriction, but at ad libitum intake, energy used for activity and maintenance was not reduced, but remained equivalent to that observed with ad libitum intake in the non-reproductive state. The information obtained regarding energy requirements for lactation in rats may not be appropriate for extrapolation to humans because rodents have high milk energy output rates relative to their total energy needs, whereas large animal species such as baboons may have more similarities to humans in their energy requirements (Roberts et al. 1985). In humans, energy expenditures of lactating and non-lactating women at rest are not necessarily significantly different (Blackburn and Calloway, 1985), although a mechanism to protect lactation, similar to the one observed in animal models, may also exist.

Smoking: Smoking reduces breastfeeding prevalence and duration (Goodine and Fried, 1984) and smoking during lactation tends to inhibit milk production (Counsilman and Mackay, 1985). Smoking may be detrimental for breast-fed infants due to the transfer of harmful substances to breast milk, including nicotine from cigarette smoke and tetrahydrocannabinol from marijuana. Consequently, breast milk may not be the best milk for infants of smoking mothers (Coveney, 1985).

IX. MATERNAL WEIGHT LOSS POSTPARTUM

Weight loss postpartum varies widely between individuals. Women delivered by cesarean section lose considerably less weight soon after parturition than do women who delivered vaginally. Women who breast-feed may lose more (Dennis & Bytheway, 1965) less (Manning-Dalton & Allen, 1983), or the same amount (Chappell et al. 1985) of weight compared with those who formula-feed; women with generalized edema in late pregnancy tend to lose more weight initially (Dennis & Bytheway, 1965). In underdeveloped countries, weight may be lost during lactation, but it may (Schutz et al. 1980) or may not necessarily (Quandt, 1983) represent a loss of body fat.

Recommendations vary, but in general, moderate and gradual weight loss or weight maintenance is recommended during lactation (Manning-Dalton & Allen, 1983) to promote breast milk production (Butte et al. 1984) and to minimize the risk of excessive trans fatty acid mobilization from maternal fat stores (Chappell et al. 1985). Although weight loss of approximately 0.5 kg per week for well-nourished mothers is unlikely to adversely affect lactation, long-term studies are needed to determine limits beyond which breast milk production is adversely affected (Strode et al. 1986).

X. COMPARISON OF COMMERCIAL INFANT FORMULAS AND BREAST MILK

Commercial infant formulas are manufactured to meet the nutritional requirements of most infants according to Recommended Dietary Allowances established by the Food and Nutrition Board of the National Research Council in the United States. Infant formulas are mixtures of fats, proteins, carbohydrates, vitamins and minerals with added thickening and stabilizing agents combined in a product designed to simulate the composition of human milk. Although nutritional deficiencies and adverse reactions had resulted from early formulations, refinement of infant formula composition during the past century and particularly during the last few years has virtually eliminated problems concerning nutrient deficiencies. Adverse reactions may still occur, most frequently related to intolerance of cow's milk used in some formulas, but products utilizing soy protein hydrolysate or meat as protein sources provide alternative infant formulas. Stringent regulations ensure that infant formulas contain the required nutrients and that quality of components, processing methods and microbial contamination are properly controlled. Consequently, infant formulas presently available are accepted as a reliable and nutritionally adequate alternative to breast-feeding (Anderson et al. 1982).

Compositions of several Canadian commercial infant formulas and mature breast milk are presented (Table 1-3). Similac and Enfalac are milk-based; ProSobee and Isomil are milk-free formulas. Because these formulas contain coconut oil and either corn or soybean oil, the fatty acid composition of formulas differs from that of breast milk.

Table 1-3 Comparison of Nutrient Composition of Four Commercial Infant Formulas[1] With Mature Breast Milk[2]

		Similac	Enfalac	ProSobee	Isomil	Breast Milk[3]
Energy KJ (kcal)		285 (68)	280 (67)	280 (67)	285 (68)	314 (75)
Carbohydrate	g	7.2	6.9	6.8	6.9	7.1
Fat	g	3.6	3.8	3.6	3.7	4.5
Linoleic Acid	g	N/A	0.75	0.70	1.00	0.034[4]
Protein	g	1.5	1.5	2.0	1.8	1.1
Ash	g	0.4	0.3	0.2	0.45	0.21
Moisture	g	-	-	-	-	N/A
Vitamin A	IU	200	210	211	200	189[5]
Vitamin D	IU	40	40	40	40	-
Vitamin E	IU	2.0	1.0	2.1	1.7	.32[5]
Vitamin C	mg	5.5	5.5	5.5	5.5	5.2
Niacin	mg	0.7	0.8	0.85	0.9	.18
Pantothenic A	mg	0.3	0.3	0.32	0.5	.25
Riboflavin	mg	0.1	0.06	0.06	0.06	.04
Thiamin	mg	0.065	0.050	0.050	0.040	.014
Vitamin B_6	mg	0.04	0.04	0.04	0.04	.018
Vitamin K_1	mg	0.0055	0.0060	0.0110	0.0100	N/A
Folic Acid	mg	0.010	0.005	0.011	0.010	.002
Biotin	mg	0.0014	0.0020	0.0050	0.0030	.0002
Vitamin B_{12}	mg	0.00015	0.00100	0.00100	0.00030	-
Sodium	mg	20	18	29	32	17
Potassium	mg	65	69	78	77	51
Chloride	mg	45	45	50	59	38
Calcium	mg	52	45	63	70	34
Phosphorus	mg	39	30	50	50	14
Magnesium	mg	4.1	4.5	6.0	5.0	3.5
Iron	mg	0.15	0.15	1.3	1.2	.05
Zinc	mg	0.5	0.4	0.53	0.5	.12
Copper	mg	0.06	0.04	0.06	0.05	.05
Manganese	mg	0.0034	0.0040	0.0200	0.0200	trace
Iodine	mg	0.010	0.004	0.007	0.010	.006
Choline	mg	8.2	8.0	8.0	8.2	1.0
Taurine	mg	4.5	N/A	N/A	4.5	N/A
Carnitine	mg	N/A	N/A	N/A	1.13	N/A
Selenium	mg	-	-	-	-	.002
Cobalt	mg	-	-	-	-	trace

1 Information was obtained from formula container labels.

2 Values are per 100 mL commercial infant formula (standard dilution) and per 100 mL fluid breast milk.

3 Adapted from Tuckerman, M.M., and Turco, S.J., Human Nutrition, 1983. pp. 157-158.

4 Adapted from Pierse, P., Van Aerde, J., and Clandinin, M.T. Nutritional value of human milk. In press.

5 Adapted from Worthington-Roberts et al., Nutrition in Pregnancy and Lactation, 1985. pp. 257.

XI. REASONS FOR BREAST-FEEDING OR FORMULA-FEEDING

The decision to breast-feed or formula-feed is most often made prior to delivery (Task Force, American Academy of Pediatrics, 1984; Fieldhouse, 1984). In particular, those women who choose to breast-feed frequently make their decision even before becoming pregnant (Mackey & Fried, 1981; Sarett et al. 1983), and most are strongly influenced by their belief that breast milk is best for their babies (Hally et al. 1984). Women who initiate breast-feeding are more often primiparous (Forman et al. 1985), white (Fetterly & Graubard, 1984), and well-educated (Martinez & Nalezienski, 1979, 1981; Task Force, American Academy of Pediatrics, 1984). Mothers who choose to bottle-feed are more commonly unmarried (Committee on Breastfeeding, Manitoba Pediatric Society, 1982), teenage (Fieldhouse, 1984), smokers (Goodine & Fried, 1984), and women who are more strongly influenced by social taboo against breast exposure in public and who consider bottle-feeding more convenient, allowing greater freedom (Task Force, American Academy of Pediatrics, 1984). Method of feeding is also influenced by previous experience (Feinstein et al. 1986), perinatal complications such as toxemia, cesarean section, and infections (Reiff & Essock-Vitale, 1985) prenatal class attendance and attitudes and beliefs of family, friends, and spouse (Lundquist Bevan et al. 1984).

XII. SUMMARY

Birth size, lactational outcome and early infant growth are affected by many diverse factors including biologic, physiologic, economic, demographic, social and cultural variables which exert their effects independently or in combination. As knowledge of these factors and their impact on infant size, growth and maternal lactation increases, the ability to ultimately influence infant health will be enhanced.

B. RATIONALE

Breast-feeding is considered ideal for most infants and vigorous promotion of a return to breast-feeding has increased both its prevalence and duration. However, early termination of breast-feeding among a large proportion of mothers continues to dominate infant feeding patterns. The primary reason for early termination of nursing has been cited as insufficient milk. Since fat stores are needed to provide energy for milk production, lactational failure due to inadequate milk quantity or quality may be a consequence of insufficient maternal fat stores due to low pre-conceptional weight or low pregnancy weight gain. Rapid or excessive weight loss during the early postpartum period may also adversely affect lactational outcome, although effects of postpartum weight loss on lactation have yet to be clearly delineated. Therefore, this study will determine the effects of maternal weight changes during pregnancy and four months postpartum on lactation and infant growth.

C. OUTLINE OF THESIS

I. Hypothesis

The research hypotheses are:

1) that increases in maternal weight gain during pregnancy improve lactational outcome

2) that minimal maternal weight loss postpartum improves lactational outcome

3) that size at birth influences rate of infant growth during the first four months of life. Size is evaluated according to net measurements and percentiles.

II. Statement of Objectives

Exclusively breast-fed and formula-fed first-born infants and their mothers will be studied to determine the influence of maternal weight changes during pregnancy on infant size at birth; and for the breast-feeding group, to determine the influence of maternal weight changes during the first four postpartum months on lactation outcome measured as infant growth.

Number of Subjects

This study will examine a minimum of 250 subjects including approximately equal numbers of breast-fed and formula-fed infants and their mothers. The number of subjects has been chosen to provide a sample size appropriate for statistical validity.

Subject Selection

Subjects will be obtained through Calgary Health Services in Calgary, Alberta by reviewing charts selected on the basis of criteria established by the investigator in accordance with the preceding literature review. Selection of maternal subjects will therefore be conducted according to age, parity and health to control variables that particularly impact on infant birth weight and lactational outcome. Accordingly, healthy, primiparous mothers between the ages of 20 and 35 years who deliver singleton infants at term, 38-41 weeks gestation, will be selected. Similarly, healthy infants without congenital defects, which might impair feeding or growth, will be included in the study sample.

Variables

Factors which affect infant birth weight and growth will be assessed. Maternal height, pregravid weight, weight gain during pregnancy, maternal age and smoking habits will be evaluated in relation to both infant birth size and early growth; infant birth size and maternal weight changes postpartum will be evaluated in relation to infant growth during the first four months of life.

D. REFERENCES

ANDERSON, S.A., CHINN, H.I., FISHER, K.D. History and current status of infant formulas. Am. J. Clin. Nutr. 35: 381-397, 1982.

AHN, C.H., MACLEAN, W.C. Growth of the exclusively breast-fed infant. Am. J. Clin. Nutr. 33: 183-192, 1980.

BAIRD, J.D., SHIRLING, D., ASHBY, J.P. Hormonal control of energy metabolism in pregnancy. Biochem. Soc. Trans. 13 (5): 822-823, 1985.

BAKER, M.R. The role of maternal stature in ethnic differences in perinatal mortality and low birth weight. Pub. Health 100: 201-204, 1986.

BEHRMAN, R.E. Preventing low birth weight: a pediatric perspective. J. Pediatr 107 (6): 842-854, 1985.

BHARGAVA, S.K., KUMARI, S., CHAUDHARY, P., BUTANI, R., SACHDEV, H.P.S. A longitudinal study of physical growth of small for date infants from birth to six years. Nutr. Res. 5: 707-713, 1985.

BHATIA, B.D., BANERJEE, D., AGARWAL, D.K., AGARWAL, K.N. Exterogestate growth: relationship with maternal body size and dietary intakes. Indian J. Pediatr. 50: 241-246, 1983.

BLACKBURN, M.W., CALLOWAY, D.H. Heart rate and energy expenditure of pregnant and lactating women. Am. J. Clin. Nutr. 42 (6): 1161-1169, 1985.

BUTTE, N.F., GARZA, C., STUFF, J.E., O'BRIAN SMITH, E., NICHOLS, B.L. Effect of maternal diet and body composition on lactational performance. Am. J. Clin. Nutr. 39: 296-306, 1984.

BUTTE, N.F., WILLS, C., JEAN, C.A., O'BRIAN SMITH, E., GARZA, C. Feeding patterns of exclusively breast-fed infants during the first four months of life. Early Hum. Dev. 12: 291-300, 1985.

CANADA. DEPARTMENT OF NATIONAL HEALTH AND WELFARE. Canadian infant feeding patterns: results of a national survey, 1982. Breast-feeding Kit. Ottawa, 1985.

CANADA. DEPARTMENT OF NATIONAL HEALTH AND WELFARE. Nutrition in pregnancy - National Guidelines. Ottawa, 1987.

CANADA. DEPARTMENT OF NATIONAL HEALTH AND WELFARE. Promoting healthy weights: a discussion paper. Ottawa, 1988.

CHAPPELL, J.E., CLANDININ, M.T. Physiology of lactation: an integrative perspective. In: Malnutrition: Determinants and Consequences. New York: Alan R. Liss, Inc., 1984. pp. 85-100.

CHAPPELL, J.E., CLANDININ, M.T., KEARNEY-VOLPE, C. Trans fatty acids in human milk lipids: influence of maternal diet and weight loss. Am. J. Clin. Nutr. 42: 49-56, 1985.

CHURELLA, H.R., BACHHUBER, W.L., MACLEAN, W.C. Survey: methods of feeding low-birth-weight infants. Pediatrics 76 (2): 243-249, 1985.

COMMITTEE ON BREAST-FEEDING, MANITOBA PEDIATRIC SOCIETY. Breast-feeding promotion in Manitoba. C.M.A. Journal 126: 639-642, 1982.

COMMITTEE ON NUTRITION, AMERICAN ACADEMY OF PEDIATRICS. On the feeding of supplemental foods to infants. Pediatrics 65 (6): 1178-1181, 1980.

COUNSILMAN, J.J., MACKAY, E.V. Cigarette smoking by pregnant women with particular reference to their past and subsequent breast feeding behavior. Aust. NZ. J. Obstet. Gynaecol. 25: 101-106, 1985.

COVENEY, J. Is breast milk the best food for all infants? Hum. Nutr. Appl. Nutr. 39 (3): 179-188, 1985.

COWARD, W.A., PAUL, A.A., PRENTICE, A.M. The impact of malnutrition on human lactation: observations from community studies. Fed. Proc. 43 (9): 2432-2437, 1984.

CRAWFORD, M.A., DOYLE, W., DRURY, P. Relationship between maternal and infant nutrition. The special role of fat in energy transfer. Trop. Geog. Med. 37(3): S5-S16, 1985.

CREASY, R.K., RESNIK, R. Intrauterine growth retardation. In: Maternal-Fetal Medicine. Philadelphia: W.B. Saunders Co., 1984a. pp. 491-510.

CREASY, R.K., RESNIK, R. Cesarean Section. In: Maternal-Fetal Medicine. Philadelphia: W.B. Saunders Co., 1984b. pp. 472-478.

CZAJKA-NARINS, D.M., JUNG, E. Physical growth of breast-fed and formula-fed infants from birth to age two years. Nutr. Res. 6: 753-762, 1986.

DENNIS, K.J., BYTHEWAY, W.R. Changes in body weight after delivery. J. Obstet. & Gynaecol. Br. Commonwealth 72: 94-102, 1965.

DIMPERIO, D.L., MAHAN, C.S. Influencing pregnancy outcome through nutrition and dietary changes. Md. Med. J. 34 (10): 997-1002, 1985.

DOBERCZAK, T.M., THORNTON, J.C., BERNSTEIN, J., KANDALL, S.R. Impact of Maternal Drug Dependency on Birth Weight and Head Circumference of Offspring. Am. J. Dis. Child. 141: 1163-1167, 1987.

DUHRING, J.L. Nutrition in pregnancy. In: Nutrition Reviews' Present Knowledge in Nutrition. Washington: The Nutrition Foundation, Inc., 1984. pp. 636-645.

DURNIN, J.V., GRANT, S., MCKILLOP, F.M., FITZGERALD, G. Is nutritional status endangered by virtually no extra intake during pregnancy? Lancet 2 (8459): 823-825, 1985.

DURNIN, J.V.G.A. Energy requirements of pregnancy - an integrated study in five countries: background and methods. Lancet 2 (8564): 895-896, 1987a.

DURNIN, J.V.G.A. Energy requirements of pregnancy in Scotland. Lancet 2 (8568): 897-900, 1987b.

DURNIN, J.V.G.A. Energy requirements of pregnancy: an integration of the longitudinal data from the five-country study. Lancet 2 (8568): 1131-1133, 1987c.

ENGLISH, R.M. Breast-milk production and energy exchange in human lactation. Br. J. Nutr. 53 (3): 459-466, 1985.

FEINSTEIN, J.M., BERKELHAMER, J.E., GRUSZKA, M.E., WONG, C.A., CAREY, A.E. Factors related to early termination of breast-feeding in an urban population. Pediatrics 78 (2):210-215, 1986.

FERRIS, A.G., LAUS, M.J., HOSMER, D.W., BEAL, V.A. The effect of diet on weight gain in infancy. Am. J. Clin. Nutr. 33: 2635-2642, 1980.

FERRIS, A.M., JENSEN, R.G. Lipids in Human Milk: A review. 2. Composition and fat-soluble vitamins. J. Ped. Gastroenterol. & Nutr. 3 (1): 108-122, 1984.

FETTERLY, K., GRAUBARD, B. Racial and educational factors associated with breast-feeding - United States, 1969 and 1980. M.M.W.R. 33 (11): 153-154, 1984.

FIELD, C.J., ANGEL, A., CLANDININ, M.T. Relationship of diet to the fatty acid composition of human adipose tissue structural and stored lipids. Am. J. Clin. Nutr. 42 (6): 1206-1220, 1985.

FIELDHOUSE, P. A revival in breast-feeding. Can. J. Public Health 75: 128-132, 1984.

FOMON, S.J. Normal growth, failure to thrive and obesity. In: Infant Nutrition. Philadelphia: Saunders, 1974. pp. 63-74.

FOMON, S.J. What are infants fed in the United States? Pediatrics 56 (3): 350-354, 1975.

FOMON, S.J., FILER, L.J., ANDERSON, T.A., ZIEGLER, E.E. Recommendations for feeding normal infants. Pediatrics 63 (1): 52-59, 1979.

FOMON, S.J., HASCHKE, F., ZIEGLER, E.E., NELSON, S.E. Body composition of reference children from birth to age 10 years. Am. J. Clin. Nutr. 35: 1169-1175, 1982.

FORMAN, M.R., FETTERLY, K., GRAUBARD, B.I., WOOTON, K.G. Exclusive breast-feeding of newborns among married women in the United States: the National Natality Surveys of 1969 and 1980. Am. J. Clin. Nutr. 42: 864-869, 1985.

GARN, S.M., PESICK, S.D. Relationship between various maternal body mass measures and size of the newborn. Am. J. Clin. Nutr. 36: 664-668, 1982.

GARTON, G.A. The composition and biosynthesis of milk lipids. J. Lipid Research 4 (3): 237-251, 1963.

GIL, G.N. Fertilization, Pregnancy and Lactation. In: Best & Taylor's Physiological Basis of Medical Practice. Edited by J.B. West. Baltimore: Williams & Wilkins, 1985. pp. 945-948.

GILLIES, M.E., NEILL, A.E. Variations in the mineral concentrations in breast milk during a single nursing, diurnally and on consecutive days. Hum. Nutr. Appl. Nutr. 39 (5): 370-375, 1985.

GOODINE, L.A., FRIED, P.A. Infant feeding practices: pre- and postnatal factors affecting choice of method and the duration of breastfeeding. Can. J. Public Health 75: 439-444, 1984.

GRIGSBY HARRISON, G., BRANSON, R.S., VAUCHER, Y.E. Association of maternal smoking with body composition of the newborn. Am. J. Clin. Nutr. 38: 757-762, 1983.

HALLY, M.R., BOND, J., CRAWLEY, J., GREGSON, B., PHILIPS, P., RUSSELL, I. Factors influencing the feeding of first-born infants. Acta. Paediatr. Scand. 73: 33-39, 1984.

HAMILL, P.V.V., DRIZD, T.A., JOHNSON, C.L., REED, R.B., ROCHE, A.F., MOORE, W.M. Physical growth: National Center for Health Statistics percentiles. Am. J. Clin. Nutr. 32: 607-629, 1979.

HARTMANN, P.E., RATTIGAN, S., SAINT, L., SUPRIYANA, O. Variation in the yield and composition of human milk. Oxf. Rev. Reprod. Biol. 7: 118-167, 1985.

HYTTEN, F., CHAMBERLAIN, G. In: Clinical Physiology in Obstetrics. Oxford: Blackwell Scientific Publications, 1980. pp. 163-175, 193-233, 385-388.

HYTTEN, F.E., LEITCH, I. Dietary requirements and dietary intakes during pregnancy. In: The Physiology of Human Pregnancy. Oxford: Blackwell Scientific Publishing Co., 1971. pp. 409-439.

JELLIFFE, D.B., JELLIFFE, E.F. The volume and composition of human milk in poorly nourished communities. A review. Am. J. Clin. Nutr. 31: 492-515, 1978.

JENSEN, R.G., BITMAN, J., WOOD, L., HAMOSH, M., CLANDININ, M.T., CLARK, R.M. Methods for the sampling and analysis of human milk lipids. In: Human Lactation: Milk Components and Methodologies. Edited by Jensen, R.G. and Neville, M.C. Plenum Publishing Corp., 1985. pp. 97-112.

KHWAJA, S.S., UDUMAN, S.A., AL-SIBAI, H., AL-SULEIMAN, S.A. The oversized infant. A study of 86 cases. Aust. NZ. J. Obstet. Gynaec. 6: 22-25, 1986.

KULSKI, J.K., SMITH, M., HARTMANN, P.E. Normal and caesarian section delivery and the initiation of lactation in women. Aust. J. Exp. Biol. Med. Sce. 59 (Pt.4): 405-412, 1981.

LAUBER, E., REINHARDT, M. Studies on the quality of breast milk during 23 months of lactation in a rural community of the Ivory Coast. Am. J. Clin. Nutr. 32: 1159-1173, 1979.

LONNERDAL, B. Biochemistry and physiological function of human milk proteins. Am. J. Clin. Nutr. 42 (6): 1299-1317, 1985.

LUMLEY, J., CORREY, J.F., NEWMAN, N.M., CURRAN, J.T. Cigarette smoking, alcohol consumption and fetal outcome in Tasmania 1981-82. Aust. NZ. J. Obstet. Gynaec. 25: 33-40, 1985.

LUNDQUIST BEVAN, M., MOSLEY, D., LOBACH, K.S., SOLIMANO, G.R. Factors influencing breast feeding in an urban WIC program. J. Am. Diet. Assoc. 84 (5): 563-567, 1984.

MACKEY, S., FRIED, P.A. Infant breast and bottle feeding practices: some related factors and attitudes. Can. J. Public Health 72: 312-318, 1981.

MANNING-DALTON, C., ALLEN, L.H. The effects of lactation on energy and protein consumption, postpartum weight change and body composition of well nourished North American women. Nutr. Res. 3: 293-308, 1983.

MARTIN, T.R., BRACKEN, M.B. The association between low birth weight and caffeine consumption during pregnancy. Amer. J. of Epidem. 126 (5): 813-821, 1987.

MARTINEZ, G.A., NALEZIENSKI, J.P. The recent trend in breast-feeding. Pediatrics 64 (5): 686-692, 1979.

MARTINEZ, G.A., NALEZIENSKI, J.P. 1980 update: the recent trend in breast-feeding. Pediatrics 67 (2): 260-263, 1981.

MCNALLY, E. HENDRICKS, S., HOROWITZ, I. A look at breast-feeding trends in Canada (1963-1982). Can. J. Public Health 76: 101-107, 1985.

METCOFF, J., COSTILOE, P., CROSBY, W.M., DUTTA, S., SANDSTEAD, H.H., MILNE, D., BODWELL, C.E., MAJORS, S.H. Effect of food supplementation (WIC) during pregnancy on birth weight. Am. J. Clin. Nutr. 41: 933-947, 1985.

MICOZZI, M.S., ALBANES, D., JONES, D.Y. Correlations of body mass indices with weight, stature, and body composition in men and women in NHANES I and II. Am. J. Clin. Nutr. 44: 725-731, 1986.

MYRES, A.W. A retrospective look at infant feeding practices in Canada: 1965-1978. J. Can. Diet. Assoc. 40 (3): 200-211, 1979.

NUTRITION COMMITTEE, CANADIAN PAEDIATRIC SOCIETY. Breast-feeding: What is left besides the poetry? Can. J. Public Health 69: 13-20, 1978.

NUTRITION COMMITTEE, CANADIAN PAEDIATRIC SOCIETY. Infant feeding. Can. J. Public Health 70: 376-385, 1979.

NUTRITION COMMITTEE, CANADIAN PAEDIATRIC SOCIETY. Infant feeding practices revisited. C.M.A. Journal 122: 987-989, 1980.

PICONE, T.A., ALLEN L.H., SCHRAMM, M.M., OLSEN, P.N. Pregnancy outcome in North American women. 1. Effects of diet, cigarette smoking, and psychological stress on maternal weight gain. Am. J. Clin. Nutr. 36: 1205-1213, 1982a.

PICONE, T.A., ALLEN, L.H., OLSEN, P.N., FERRIS, M.E. Pregnancy outcome in North American women. II. Effects of diet, cigarette smoking, stress, and weight gain on placentas, and on neonatal physical and behavioral characteristics. Am. J. Clin. Nutr. 36: 1214-1224, 1982b.

PIERSE, P., VAN AERDE, J., CLANDININ, M.T. Nutritional value of human milk. In press.

PITA, M.L., MORALES, J., SANCHEZ-POZO, A., MARTINEZ-VALVERDE, J.A., GIL, A. Influence of the mother's weight and socioeconomic status on the fatty acid composition of human milk. Ann. Nutr. Metab. 29 (6): 366-373, 1985.

PRENTICE, A., PRENTICE, A.M., WHITEHEAD, R.G. Breast-milk fat concentrations of rural African women. 1. Short-term variations within individuals. Br. J. Nutr. 45: 483-494, 1981a.

PRENTICE, A., PRENTICE, A.M., WHITEHEAD, R.G. Breast-milk fat concentrations of rural African Women. 2. Long-term variations within a community. Br. J. Nutr. 45: 495-503, 1981b.

PRENTICE, A. The influence of maternal parity on breast-milk composition. In: Composition and Physiological Properties of Human Milk. Edited by J. Schaub. Elsevier Science Publishers B.V. (Biomedical Division), 1985. pp. 309-319.

PRENTICE, A.M., ROBERTS, S.B., PRENTICE, A., PAUL, A.A., WATKINSON, M., WATKINSON, A.A., WHITEHEAD, R.G. Dietary supplementation of lactating Gambian women. I. Effect on breast-milk volume and quality. Hum. Nutr. Clin. Nutr. 37C: 53-64, 1983.

QUANDT, S.A. Changes in maternal postpartum adiposity and infant feeding patterns. Amer. J. Phys. Anthropol. 60: 455-461, 1983.

QUANDT, S.A. The effect of beikost on the diet of breast-fed infants. J. Amer. Diet. Assoc. 84 (1): 47-51, 1984.

RATTIGAN, S., GHISALBERTI, A.V., HARTMANN, P.E. Breast-milk production in Australian woman. Br. J. Nutr. 45: 243-249, 1981.

REIFF, M.I., ESSOCK-VITALE, S.M. Hospital influences on early infant-feeding practices. Pediatrics 76 (6): 872-879, 1985.

ROBERTS, S.B., COWARD, W.A. Lactation increases the efficiency of energy utilization in rats. J. Nutr. 114: 2193-2200, 1984.

ROBERTS, S.B., COLE, T.J., COWARD, W.A. Lactational performance in relation to energy intake in the baboon. Am. J. Clin. Nutr. 41: 1270-1276, 1985.

ROSSO, P. A new chart to monitor weight gain during pregnancy. Am. J. Clin. Nutr. 41: 644-652, 1985.

ROWLAND, M.G.M. The "why" and "when" of introducing food to infants: growth in young breast-fed infants and some nutritional implications. Am. J. Clin. Nutr. 41: 459-463, 1985.

SAINT, L., SMITH, M., HARTMANN, P.E. The yield and nutrient content of colostrum and milk of women from giving birth to one month post-partum. Br J. Nutr. 52: 87-95, 1984.

SARETT, H.P., BAIN, K.R., O'LEARY, J.C. Decisions on breast-feeding or formula feeding and trends in infant-feeding practices. Am. J. Dis. Child. 137: 719-725, 1983.

SCHELL, L.M., HODGES, D.C. Variation in size at birth and cigarette smoking during pregnancy. Am. J. Phys. Anthropol. 68 (4): 549-554, 1985.

SCHUTZ, Y., SECHTIG, A., BRADFIELD., R.B. Energy expenditures and food intakes of lactating women in Guatemala. Am. J. Clin. Nutr. 33: 892-902, 1980.

SHIONO, P.H., KLEBANOFF, M.A., GRAUBARD, B.I., BERENDES, H.W., RHOADS, G.G. Birth weight among women of different ethnic groups. J. Amer. Med. Assoc. 255 (1): 48-52, 1986a.

SHIONO, P.H., KLEBANOFF, M.A., RHOADS, G.G. Smoking and drinking during pregnancy: their effects on preterm birth. J. A. M. A. 255 (1): 82-84, 1986b.

SMITH, C.A. Effects of maternal undernutrition upon the newborn infant in Holland (1944-1945). J. Pediatr. 30 (3); 229-243, 1947.

SPADY, D.W., ATRENS, M.A., SZYMANSKI, W.A. Effects of mother's smoking on their infants' body composition as determined by total body potassium. Ped. Res. 20 (8): 716-719, 1986.

STEWART, P.J., DUNKLEY, G.C. Smoking and health care patterns among pregnant women. Can. Med. Assoc. J. 133: 989-994, 1985.

STRODE, M.A., DEWEY, K.G., LONNERDAL, B. Effects of short-term caloric restriction on lactational performance of well-nourished women. Acta Paediatr Scand 75: 222-229, 1986.

STUFF, J.E., GARZA, C., BOUTTE, C., FRALEY, J.K., O'BRIEN SMITH, E., ROSELAND KLEIN, E., NICHOLS, B.L. Sources of variance in milk and caloric intakes in breast-fed infants: implications for lactation study design and interpretation. Am. J. Clin. Nutr. 43: 361-366, 1986.

TASK FORCE, AMERICAN ACADEMY OF PEDIATRICS. Report of the task force on the assessment of the scientific evidence relating to infant-feeding practices and infant health. Pediatrics 74 (4) Pt. 2 Suppl: 579-647, 1984.

TUCKERMAN, M.M., TURCO, S.J. Feeding the normal infant. In: Human Nutrition. Philadelphia: Lea & Febiger, 1983. pp. 156-165.

TYSON, J.E., LASKY, R.E., MIZE, C.E., RICHARDS, C.J., BLAIR-SMITH, N., WHYTE, R., BEER, A.E. Growth, metabolic response, and development in very-low-birth-weight infants fed banked human milk or enriched formula. I. Neonatal findings. J. Ped. 103: 95-104, 1983.

VAN DER SPUY, Z.M. Nutrition and reproduction. Clin. Obstet. Gynaecol. 12 (3): 579-604, 1985.

WALKER, D.A., ABERNATHY, T.J., MALOFF, B.M.K., LOHNES, A.E. Infant feeding practices in Calgary during 1984. J. Can. Diet. Assoc. 48 (2): 108-112, 1987.

WALKER, W.A., WATKINS, J.B. In: Nutrition in Pediatrics: Basic Science and Clinical Application. Boston: Little, Brown and Co., 1985. pp. 78-83.

WIDDOWSON, E.M. Changes in body proportions and composition during growth. In: Scientific Foundations of Paediatrics. Edited by J.A. Davis and J. Dobbing. London: William Heinemann Medical Books, 1974. pp. 153-163.

WORTHINGTON-ROBERTS, B. Preconceptional and prenatal nutrition. Part I - energy, protein, and related issues. J. Can. Diet Assoc. 46 (3): 169-175, 1985.

WORTHINGTON-ROBERTS, B., VERMEERSCH, J. In: Nutrition in Pregnancy and Lactation. St. Louis: Times Mirror/Mosby College Publishing, 1985. pp. 61-131.

YEUNG, D.L., PENNELL, M.D., LEUNG, M., HALL, J. Infant feeding practices. Nutr. Rep. Int. 23 (2): 249-260, 1981a.

YEUNG, D.L., PENNELL, M.D., LEUNG, M., HALL, J. Breastfeeding: prevalence and influencing factors. Can. J. Public Health 72: 323-330, 1981b.

YIP, R. Altitude and birth weight. J. Pediatr 111: 869-876, 1987.

ZIEGLER, E.E., O'DONNELL, A.S., NELSON, S.E., FOMON, S.J. Body composition of the reference fetus. Growth 40: 329-341, 1976.

CHAPTER 2

EFFECTS OF MATERNAL WEIGHT, WEIGHT CHANGES DURING PREGNANCY, WEIGHT CHANGES POSTPARTUM AND MATERNAL SMOKING ON LACTATION OUTCOME REFLECTED BY EARLY INFANT GROWTH

A. INTRODUCTION

Approval for the study was obtained on March 27, 1986 from Calgary Health Services' Research and Development Committee. Calgary Health Services is a government-funded public agency which provides community health services to the city of Calgary and surrounding district. Calgary is a city with a population of 625,000 people, located in southern Alberta. At the present time, there are more than 12,000 babies born in Calgary each year. Calgary Health Services documents all live births, and through its eleven Community Health Clinics and its centrally computerized Infant Health Monitoring system, follows the growth and development of each child for at least the first six months of life. Due to the large number of births per year and the unique public health documentation system operated by Calgary Health Services, Calgary was chosen as an ideal location for this study.

B. MATERIALS AND METHODS

I. Calgary Health Services' Protocol

On January 1, 1984, Calgary Health Services instituted its new Infant Health Monitoring System. This system provides for detailed accounting of health information pertaining to each child born to Calgary residents since the installation of the system in 1984. Notification of each birth is sent to the agency via the "Physician's Notice of Birth" (Appendix). The information contained in this document including date of birth, gestational age, mother's age, details of delivery, pertinent medical information, and infant's length, weight and head circumference measured at time of hospital discharge or within seven days of birth is recorded on computer. Within one to two days of receiving the "Physician's Notice of Birth", Calgary Health Services' central agency assigns a "Health Record Number" to each newborn and sends the number with a copy of the "Child Health Record" (Appendix) to the Community Health Clinic closest to the residence of the infant. The "Child Health Record" is used to document feeding, immunization, illness, injury and development of the child from birth to age 18. The form is completed by Community Health nurses according to standardized protocol. During the infant's first six months of life, information is recorded on the "Child Health Record" during a home visit conducted within ten days of hospital discharge and at the Community Health Clinic when the infant is immunized. At the home visit, nurses record maternal height, prepregnancy weight and pregnancy weight gain as reported by the mother. General health information for the new infant and method of feeding are also established at that time.

The immunization protocol in Calgary requires that infants be immunized at two, four and six months of age. This protocol facilitates regular collection of information pertaining to infant growth and feeding patterns. Thus, infant length, weight, head circumference and feeding history are recorded at the clinics at two, four and six months of life. Nurses weigh and measure infants (undressed, no diaper); weigh scales are calibrated by an outside company. Following the six month immunization, the Child Health Record is submitted to the central agency for computerization; the remaining record is retained by the Community Health Clinic.

II. Study Design

The number of subjects was chosen to provide a sample size appropriate for statistical validity, based on calculations using the formula $n=[(t^2s^2) \times (d^2)^{-1}]$ where t = the tabulated value for desired confidence level and degrees of freedom of the sample, s = sample variance, d = half-width of the desired confidence interval (in our case this was 0.1), and n = total number of observations required. Variance was estimated on the basis of work by Ahn et al. (1980) related to growth of exclusively breast-fed infants, and from this work we estimated variance to be 0.5. Thus, where d = 0.1, n = 125; and therefore, a sample size of 250 was chosen, including 125 subjects in each of the two groups.

Since several studies were being conducted concurrently under the auspices of Calgary Health Services and since the agency wished to protect the privacy of its clients, Community Health Nurses in all eleven Calgary Health Services' clinics were asked to collect data rather than allow the investigator to contact individual subjects. The Community Health nurses were asked for their cooperation in collecting data for the study, but were informed that in order to minimize bias, the purpose of the study would not be disclosed until its completion. Although the desire to minimize bias was well-intended, one disadvantage of this approach may have been a reduction in the nurses' interest in the study or appreciation for its relevance which could, in turn, have indirectly lessened subject participation. This potential effect was not evaluated, but was believed to have been minimal; the effort put forth by the nurses in collecting data was appreciated at all times.

Between May 1986 and March 1987, Calgary mothers and their newborn infants registered on the Infant Health Monitoring System were screened by computer to determine whether or not they met the initial study criteria described on pages 51 and 52. Those who qualified for the study were referenced in a separate computer file that was later accessed by the investigator.

A standardized form to facilitate collection of new information for the study was designed and distributed to the Community Health Clinics for each of the computer-selected subjects. When the nurses visited the new mothers and their infants at home approximately one week after hospital discharge (or in the case of home deliveries, soon after birth), the nurses introduced the study, showed prospective subjects the form, and asked them to participate. Little information regarding the purpose of the study was extended to the mothers; in general they were told the study was related to nutrition and infant growth. This was, incidentally, the nurses' interpretation of the study's purpose. In order to complete the "Study of Infant Weight Gain" form (Fig. 2-1), the nurses were required to ask the mothers their body weights and their smoking habits at one week, two months and four months postpartum and their smoking habits during pregnancy. Body weights were self-reported by the mothers since there was no means for the nurses to verify maternal weights. Not all of the clinics contained scales and the nurses did not have portable scales to carry to the home visit. For the smoking data, mothers were simply asked it they had smoked "at all" during the four time periods. The information was recorded at the home visit (one week postpartum) and at the two and four month clinic visits. However, occasionally someone other than the mother took the infant to the clinic for immunization and consequently no maternal data could be recorded at that time.

STUDY OF INFANT WEIGHT GAIN

INFANT HEALTH RECORD NUMBER ____________________

MOTHER'S WEIGHT AT

1st Home Visit	__________	☐ Lbs.	☐ Kilo's
2 mo. Clinic Visit	__________	☐ Lbs.	☐ Kilo's
4 mo. Clinic Visit	__________	☐ Lbs.	☐ Kilo's

WAS MOTHER SMOKING AT ALL :

During Pregnancy

At time of 1st home visit	_____	☐ Yes	☐ No
At time of 2mo. clinic visit	_____	☐ Yes	☐ No
At time of 4 mo. clinic visit	_____	☐ Yes	☐ No

* This form is to be kept with the child's health record until collected in the Fall of 1986. If you have questions, please call Dr. Abernathy at 228-7535.

Figure 2-1 "Study of Infant Weight Gain" form designed for collection of new data in the present study

III. Subjects

Sixteen hundred primiparous mothers between the ages of 20 and 35 years and their full-term, singleton infants born at 38-41 weeks gestation were computer-selected for the study. Both married and single mothers and their infants were included. Initial exclusion criteria required that mothers who were on medication or who were not the natural parents of the children and that infants diagnosed with congenital heart defects were excluded. Surnames of selected mothers and Health Record Numbers of their infants were then provided to the investigator. Approximately four months after the infants' births, the investigator visited the clinics to review charts and establish further eligibility for the study.

Each of the 1600 computer-selected charts was reviewed by the investigator to determine health status of mother and child and feeding patterns for the first four months of life. Mothers or infants displaying significant illness or conditions which might interfere with feeding were to be excluded from the study, including mothers with diagnosed diabetes, pernicious anemia, Rh incompatibility, pregnancy-induced hypertension with proteinuria or antepartum hemorrhage, and infants with cleft palate. Infants who had been solely breast-fed or solely formula-fed from the first week of life to four months of age were selected. Introduction of solid foods and juices was permitted after two months of age, but provision of milks or milk substitutes other than breast-milk and formula for the two respective groups was not allowed past the first week home after discharge from hospital.

After visiting each of the eleven Community Health Clinics six times during a period of seven months, a sample of 297 mother-infant pairs was selected. Forty subjects were subsequently deleted from the study because the home visit, two month or four month clinic visits did not occur within a reasonable period of time. Subjects were excluded if the visits did not occur within 25 days, 60-85 days, and 120-145 days after birth for the home visit, two month clinic visit, and four month clinic visit, respectively. Confidentiality of information pertaining to all subjects was strictly maintained according to agreement with Calgary Health Services. The final sample for analysis consisted of 257 pairs of subjects including 141 exclusively breast-fed infants and 116 exclusively formula-fed infants and their mothers.

IV. Data Collection and Analysis

Data for the study was acquired from the "Physician's Notice of Birth", "Child Health Record" and "Study of Infant Weight Gain" forms. Validation that the data recorded by the investigator was accurate was conducted by Dr. Thomas Abernathy, Director of the Division of Research and Development at Calgary Health Services. Dr. Abernathy randomly chose data for a 5% sample of the 257 subjects to compare values reported by the investigator with those reported by the nurses and entered on computer at the health agency. It was established by Dr. Abernathy that an appropriate level of accuracy was maintained.

The Mainframe Computer at the University of Alberta was used for computerization of data. Statisical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) to provide Pearson correlations, tests of regression coefficients and analysis of variance. Duncan's multiple range test and the Student's t-test were also performed.

The Student's t-test was used to compare maternal characteristics for mothers who were breast-feeding or formula-feeding, smoking or non-smoking. Oneway analysis of variance was used to compare infants' birth size and growth for groups according to their sex, gestational age, milk or formula-feeding, time at which solid foods were started, and maternal smoking habits. Duncan's Multiple Range Test was utilized for multiple comparisons pertaining to both maternal and infant characteristics, and Pearson correlations for evaluation of corresponding infant and maternal weight changes postpartum. A level of statistical significance was determined if probability (p) was less than 0.05. A stepwise multiple regression procedure was used to examine correlations between both infant weight at birth and infant weight gain (dependent variables) and maternal characteristics (independent variables) including maternal age, height, pregravid weight, weight gain during pregnancy, and length of gestation. The impact of infant weight at birth on subsequent infant growth during the first four months of life was also evaluated within the multiple regression equation.

C. RESULTS

I. Description of Sample

Two hundred and fifty seven mothers and their first-born infants, 119 males and 138 females, were selected. The study population was divided into two groups according to method of infant feeding from the first week home following hospital discharge until the infant reached four months of age. Accordingly, 141 infants (63 males, 78 females) were exclusively breast-fed and 116 infants (56 males, 60 females) were exclusively formula-fed.

Subjects were acquired from all regions of the city of Calgary represented by eleven Community Health Clinics. Individuals who met the study criteria were incorporated into the study in a chronological manner; there was no inherent bias in the selection of subjects. The distribution of subjects by clinic is illustrated (Table 2-1). In general, each clinic provides health services to the population located geographically close to the clinic. Because various areas of the city differ in age distribution, ethnicity and socio-economic status, the distribution of subjects by clinic in part reflects the profile of the population surrounding the clinic. For example, Ranchlands' Calgary Health Services Clinic services a typically young, middle-class, well-educated population where a large proportion of new mothers exclusively breast-feed their infants. The Downtown clinic services a typically low income population, many of whom speak limited English and have little formal education, and a large proportion of new mothers either formula-feed their infants or provide formula supplements. Although the proportion varied, all clinics did contribute subjects for both breast-fed and formula-fed groups.

Table 2-1 Distribution of Subjects by Community Health Clinics in Calgary

Clinic Name	Clinic Number	No. of Subjects	% Distribution
North Hill	1	17	6.6
Thornhill	2	38	14.8
Ranchlands	3	44	17.1
Downtown	4	9	3.5
Northgate	6	20	7.8
Forest Lawn	7	18	7.0
Haysboro/Ogden	8	22	8.6
South District	9	27	10.5
Scarboro	10	17	6.6
Shaganappi	11	22	8.6
Village Square	12	23	8.9
Total		257	100.0

A wide variety of ethnic groups was represented in the study population. Although ethnicity was, by protocol, not recorded on the clinic charts, sometimes mention of ethnic background was made in the nurses' notes to assist staff in obtaining a language interpreter or to identify specific health requirements such as immunization for immigrant parents. Although the majority of subjects were apparently of European decent, a small number of subjects were identified as Vietnamese, Thai, native Indian, Oriental, Lebanese, Egyptian, Indian, Sri Lankan and Phillipino. Ethnicity is of interest due to its relationship with maternal size, infant size at birth and cultural differences in infant feeding practices. However, since there was no systematic recording of ethnicity on the clinic charts, the ethnic distribution was unknown and therefore it was not possible to conduct analyses by ethnicity.

The Community Health nurses reported that many of the mothers selected for the study were unhappy about the questions they were asked regarding their postpartum weights. These mothers indicated they "felt fat" and self-conscious postpartum, and perceived the questions an intrusion on their privacy. Some women refused to participate in the study, but how many refused and whether they were overweight and to what degree is not known. Furthermore, some mothers who disapproved of the questions pertaining to their weight, but nevertheless consented to participate in the study, complained each time they were asked to report their weight or subsequently refused to answer weight-related questions.

II. Mothers' Profile

1. Breast-Feeding and Formula-Feeding Mothers

For the 257 women who participated in the study, breast-feeding mothers (n=141) were slightly older than formula-feeding mothers (n=116) and the difference was statistically significant (26.9 vs. 25.7 yrs, $p<0.01$) (Table 2-2). There was no significant difference between the breast-feeding and formula-feeding groups for maternal height, pregravid weight, weight gain during pregnancy, postpartum weight at the Home Visit, two month and four month Clinic Visits, or length of gestation. For breast-feeding mothers, mean height was 164.2 cm (64.5 in; range 138.5 cm to 177.8 cm) and mean pregravid weight was 58.3 kg (128 lb; range 41.8 kg to 94.5 kg), whereas for formula-feeding mothers, mean height was 163.0 cm (64.0 in; range

132.1 cm to 182.9 cm) and mean pregravid weight was 58.5 kg (129 lb; range 33.2 kg to 125.0 kg). Average weight gain during pregnancy was 14.6 kg (32 lb; range 6.8 kg to 30.9 kg) for the breast-feeding group and 15.0 kg (33 lb; range 2.2 kg to 31.8 kg) for the formula-feeding group. Maternal weight at the Home Visit was approximately 4.5 kg (10 lb) higher than the mothers' usual weight. At two months postpartum the breast-feeding group (n=118) had lost 1.8 $\pm$ 0.2 (SE) kg (4.0 lb) while the formula-feeding group (n=89) had lost 2.3 $\pm$ 0.3 (SE) kg (5.1 lb). Weight loss from two to four months postpartum was 1.1 $\pm$ 0.2 (SE) kg (2.4 lb) for breast-feeding (n=121) and 1.4 $\pm$ 0.2 (SE) kg (3.1 lb) for formula-feeding (n=90) mothers. From birth to four months, weight changes in the breast-feeding group ranged from losses of 9.1 kg to gains of 6.8 kg, and in the formula-feeding group, from losses of 14.1 kg to gains or 4.6 kg. By four months postpartum neither group had resumed its former average pregravid weight. Interestingly, the two groups were almost identical in weight both pregravid and at four months postpartum. Both groups delivered their babies just under 40 weeks gestation and all babies were delivered vaginally. The formula-feeding group had a higher incidence of smokers, with 34% of formula-feeding mothers reporting to have smoked compared with only 12% of breast-feeding mothers.

2. Smoking and Non-Smoking Mothers

For subjects who had reported smoking "at all' during pregnancy, at the Home Visit, or at the two month or four month Clinic Visits, (Table 2-3), smoking mothers (n=56) were younger than non-smoking mothers (n=176) and the difference was statistically significant (24.1 vs. 27.0 yrs, $p<0.01$). There was no significant difference between

Table 2-2 Comparison Between Breast-Feeding and Formula-Feeding Mothers for Age, Height, Pregravid Weight, Weight Change During Pregnancy, Weight Change Four Months Postpartum, Length of Gestation and Smoking Habits[1-3]

		Breast-Feeding	Formula-Feeding
Age (yr)		26.9 ± 0.3(141)*	25.7 ± 0.4(116)
Height (cm)		164.2 ± 0.6(140)	163.0 ± 0.7(116)
Pregravid weight (kg)		58.3 ± 0.7(141)	58.5 ± 1.2(115)
Weight gain during pregnancy (kg)		14.6 ± 0.4(141)	15.0 ± 0.5(116)
Weight at Home Visit (kg)		63.1 ± 0.7(124)	63.6 ± 1.2(101)
Weight at 2 months postpartum (kg)		61.2 ± 0.7(135)	62.1 ± 1.3(101)
Weight at 4 months postpartum (kg)		60.5 ± 0.7(126)	60.4 ± 1.2 (98)
Length of gestation (wks)		39.6 ± 0.1(141)	39.7 ± 0.1(116)
Smoking[4]	- Yes	17	39
	- No	111	65
	- Unknown	13	12

[1] Values are means ± S.E. Numbers in parentheses indicate number of observations per mean.

[2] Smoking is defined as any smoking during pregnancy and four months postpartum.

[3] Statistical significance is based on Students's t-test. Means on the same line with an asterisk are significantly different, $p<0.01$.

[4] Complete data for smoking during pregnancy and at Home Visit, two month and four month clinic visits were available for subjects categorized as Smoking (Yes,No). Data missing at any time resulted in categorization of subjects under Smoking (Unknown).

Table 2-3 Comparison Between Smoking and Non-Smoking Mothers for Age, Height, Pregravid Weight, Weight Change During Pregnancy, Weight Change Four Months Postpartum and Length of Gestation[1-3]

	Smoking	Non-Smoking
Age (yr)	24.1 ± 0.4(56)*	27.0 ± 0.3(176)
Height (cm)	164.5 ± 0.8(55)	164.0 ± 0.5(176)
Pregravid weight (kg)	5[illegible].7 ± 1.2(56)	59.1 ± 0.8(175)
Weight gain during pregnancy (kg)	16.1 ± 0.7(56)	14.5 ± 0.4(176)
Weight at Home Visit (kg)	64.1 ± 1.4(50)	64.1 ± 0.8(152)
Weight at 2 months postpartum (kg)	63.0 ± 1.7(48)	62.1 ± 0.8(166)
Weight at 4 months postpartum (kg)	61.7 ± 1.7(45)	61.0 ± 0.8(160)
Length of gestation (wks)	39.8 ± 0.1(56)	39.6 ± 0.1(176)

1 Smoking is defined as any smoking during pregnancy and four months postpartum.

2 Values are means ± S.E. Numbers in parentheses indicate number of observations per mean.

3 Statistical significance is based on Student's t-test. Means on the same line with an asterisk are significantly different, $p<0.01$.

the smoking and non-smoking groups for height, pregravid weight, weight gain during pregnancy, postpartum weight at the Home Visit, two month and four month Clinic Visits, or length of gestation. There was a slight but non-significant difference in pregnancy weight gain between the two groups, with the smoking group gaining 1.6 kg (3.5 lb) more than the non-smoking group. Non-smoking mothers lost slightly more weight (NS) during the first four postpartum months.

Unfortunately, smoking data was not obtained for 25 of the 257 subjects. On several occasions, nurses in the community health clinics apologized to the investigator for not having recorded smoking information, stating that they had forgotten to ask mothers the pertinent questions. Consequently, 25 women were excluded from the statistical analysis of smoking and non-smoking mothers.

III. Infants' Profile

1. Infant Birth Weight

The average weight at birth for infant subjects was 3.4 kg (7.4 lb) $\pm$ 0.04 (SE) for male infants and 3.3 kg (7.2 lb) $\pm$ 0.04 (SE) for female infants. The distribution of infant birth weight according to percentiles for this population is outlined (Table 2-4). In addition to variations in birth weight according to sex, there was a significant difference in birth weight relative to gestational age (Table 2-5). The differences between mean birth weights from gestational age 38 to 39 weeks, 39 to 40 weeks and 40 to 41 weeks were 179 g, 220 g and -1 g for males and 49 g, 234 g and -41 g for females, respectively.

In this study, six babies, three males and three females, weighed 2500 grams or less (mean wt. 2438 g, range 2310-2485 g) resulting in

Table 2-4 Distribution of Infant Birth Weight by Percentiles

	Male Infants		Female Infants	
Percentiles	(kg)	(lb)	(kg)	(lb)
5	2.6	5.8	2.6	5.7
10	2.7	6.0	2.7	6.1
25	3.1	6.8	3.0	6.6
50	3.4	7.4	3.3	7.2
75	3.7	8.2	3.6	7.9
90	3.9	8.6	3.9	8.5
95	4.1	9.0	4.1	9.0

Table 2-5 Distribution of Infant Birth Weight by Gestational Age[1,2]

	Gestational Age (wks)			
	38	39	40	41
Males	3.065 ± 0.1^{A}	3.244 ± 0.1^{A}	3.464 ± 0.1^{B}	3.463 ± 0.1^{B}
	(19)	(24)	(55)	(21)
Females	3.112 ± 0.1^{a}	3.161 ± 0.1^{a}	3.395 ± 0.05^{b}	3.354 ± 0.1^{ab}
	(16)	(34)	(72)	(16)

[1] Values are means ± S.E. Numbers in parentheses indicate number of observations per mean.

[2] Statistical significance is based on analysis of variance. Means in a row (across) with the same superscript are not significantly different, $p<0.05$.

their classification as low-birth-weight infants. One infant was breast-fed; the remaining five were formula-fed. For these low birth weight infants, mean values for maternal height, weight, and pregnancy weight gain were 156.8 cm (61.7 in), 46.7 kg (102.8 lb) and 10.1 kg (22.2 lb), respectively. Maternal pregnancy weight gain ranged from 4.08 to 15.8 kg. Weight for Height Ratio Index was 0.19, mean length of gestation was 39.2 weeks and mean maternal age was 26.3 years. Only one of the six mothers reported smoking during pregnancy.

2. Breast-Fed and Formula-Fed Infants

Significant differences in infant size were observed when the breast-fed and formula-fed groups were compared (**Table 2-6**). Mean gestational ages for breast-fed and formula-fed male and female infants were not significantly different, ranging from 39.6 to 39.8 weeks. Breast-fed male infants were larger at birth ($p<0.05$) than both male and female formula-fed infants for length, weight, and head circumference. Breast-fed males were also larger ($p<0.05$) than breast-fed females for head circumference.

For male infants, the rate of weight gain during the first four months of life was very similar for breast-fed and formula-fed babies; consequently, their weights were significantly different at two and four months as well as at birth. However, formula-fed males grew more rapidly than breast-fed males in both length and head circumference with the result that these parameters were significantly different for the two groups at birth but not at four months of age.

For female infants, there were no significant differences between the breast-fed and formula-fed groups for length, weight or head circumference at birth. Both groups grew at very similar rates during

Table 2-6 Breast-Fed and Formula-Fed Infants' Size at Birth, Two Months and Four Months of Age[1,2]

	Breast-Fed Infants		Formula-Fed Infants	
	Males	Females	Males	Females
Gestational Age (wks)	39.6 ± 0.1 (63)	39.7 ± 0.1 (78)	39.8 ± 0.1 (56)	39.6 ± 0.1 (60)
Length (cm)				
- Birth	52.7 ± 0.3^{a}(63)	52.0 ± 0.2^{ab}(77)	51.3 ± 0.3^{b} (56)	51.4 ± 0.3^{b}(58)
- 2 Months	59.5 ± 0.2^{a}(63)	58.3 ± 0.2^{b} (78)	58.2 ± 0.3^{b} (56)	57.6 ± 0.3^{b}(60)
- 4 Months	64.4 ± 0.3^{a}(63)	62.9 ± 0.2^{b} (78)	63.8 ± 0.3^{a} (56)	62.7 ± 0.3^{b}(60)
Weight (kg)				
- Birth	3.5 ± 0.1^{a}(63)	3.4 ± 0.05^{ab}(78)	3.2 ± 0.1^{b} (56)	3.2 ± 0.1^{b}(60)
- 2 Months	5.8 ± 0.1^{a}(63)	5.3 ± 0.1^{b} (78)	5.4 ± 0.1^{c} (56)	5.1 ± 0.1^{b}(60)
- 4 Months	7.1 ± 0.1^{a}(63)	6.4 ± 0.1^{b} (78)	6.7 ± 0.1^{c} (56)	6.4 ± 0.1^{b}(60)
Head Circumference (cm)				
- Birth	34.8 ± 0.2^{a}(63)	34.1 ± 0.1^{b} (77)	34.0 ± 0.2^{b} (56)	33.9 ± 0.2^{b}(58)
- 2 Months	40.3 ± 0.1^{a}(62)	39.2 ± 0.1^{c} (76)	40.0 ± 0.1^{ab}(55)	38.9 ± 0.1^{c}(58)
- 4 Months	42.6 ± 0.2^{a}(63)	41.3 ± 0.1^{c} (75)	42.4 ± 0.2^{ab}(53)	41.2 ± 0.1^{c}(58)

[1] Values are means ± S.E. Numbers in parentheses indicate number of observations per mean.

[2] Statistical significance is based on oneway analysis of variance and Duncan's multiple range test. Means in a row (across) with the same superscript or without superscripts are not significantly different, $p<0.05$.

the first four months with the result that length, weight and head circumference were not significantly different during that time.

In general, female infants grew more slowly than male infants in length, weight, and head circumference throughout the first four months of life. This observation was expected, since this pattern of growth for male and female infants has been well documented by the National Center for Health Statistics in the United States.

Mean values for length, weight and head circumference for male and female breast-fed and formula-fed babies were converted into percentages of growth for two month periods, from birth to two months and from two to four months of age. Formula-fed male babies exhibited the greatest percentage growth in length, weight and head circumference followed in descending order of growth by breast-fed males, formula-fed females, and lastly, breast-fed female infants. The rate of growth during the first two months of life far exceeded the rate of growth between two and four months, particularly for weight. The rate of weight gain during the first two months was more than double the rate recorded for two to four months (Fig. 2-2).

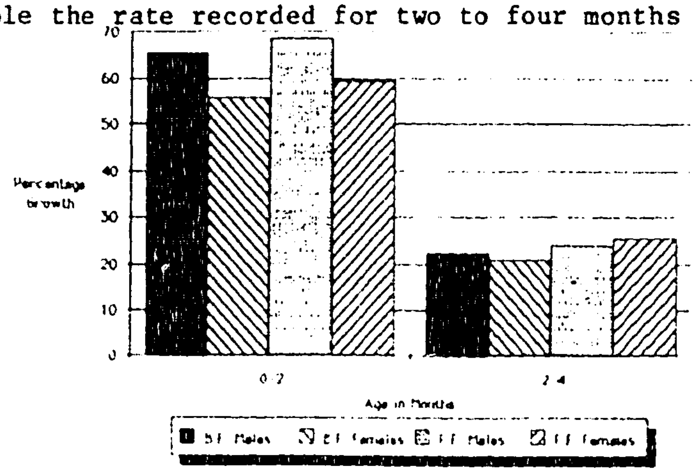

Figure 2-2 Percentage growth in weight for breast-fed and formula-fed infants during the first four months of life

3. Introduction of Solid Foods

The first feeding of solid foods occurred at a mean age of 3.6 months for breast-fed infants and at 3.2 and 3.0 months for formula-fed males and females, respectively. To determine whether or not the feeding of solids affected early infant growth, breast-fed and formula-fed infants were divided into groups according to their introduction to solids during the second, third or fourth months of life (Tables 2-7, 2-8). For breast-fed babies, only two infants (1%) received solids between two and three months of age whereas 52 (39%) received solids between three and four months and 82 (61%) received solids between four and five months of age. Five breast-fed babies were first fed solids after five months. For formula-fed babies, 21 infants (19%) received solids between two and three months, 62 (55%) received solids between three and four months and 29 (26%) received solids between four and five months of age. Two formula-fed babies were fed solids after five months. When infants were divided by sex, patterns of growth were similar within groups of breast-fed and formula-fed infants whether solids were introduced in the second, third or fourth month.

4. Comparison of Infant Birth Size With NCHS Percentiles

A comparison of infant subjects' anthropometric measurements with National Center for Health Statistics (NCHS) percentiles indicated that both similarities and differences appear to exist between Calgary infants and norms established for American infants (Table 2-9). In the present study, breast-fed babies had higher percentile scores than formula-fed infants for length, weight and head circumference. Both groups had relatively high percentile scores for length but average

Table 2-7 Breast-Fed and Formula-Fed Male Infants' Size at Birth, Two Months and Four Months of Age When Solids Were First Fed During the Second, Third or Fourth Months of Life[1-3]

	Growth When Solids Were Fed to Breast-Fed Infants			Growth When Solids Were Fed to Formula-Fed Infants		
Length (cm)	2 months	3 months	4 months	2 months	3 months	4 months
Birth	(0)	52.2 ± 0.5(25)	53.0 ± 0.3(36)	50.6 ± 1.0(7)	51.5 ± 0.4(31)	51.0 ± 0.7(16)
2 Months	(0)	59.1 ± 0.3(25)	59.8 ± 0.3(36)	57.8 ± 0.6(7)	58.5 ± 0.4(31)	57.7 ± 0.6(16)
4 Months	(0)	64.0 ± 0.4(25)	64.7 ± 0.4(36)	63.1 ± 0.6(7)	64.3 ± 0.5(31)	63.3 ± 0.5(16)
Weight (kg)						
Birth	(0)	3.4 ± 0.1(25)	3.5 ± 0.1(36)	3.1 ± 0.1(7)	3.3 ± 0.1(31)	3.1 ± 0.1(16)
2 Months	(0)	5.7 ± 0.1(25)	5.9 ± 0.1(36)	5.4 ± 0.1(7)	5.4 ± 0.1(31)	5.4 ± 0.1(16)
4 Months	(0)	7.0 ± 0.2(25)	7.2 ± 0.1(36)	6.6 ± 0.1(7)	6.7 ± 0.1(31)	6.8 ± 0.2(16)
Head Circumference (cm)						
Birth	(0)	34.5 ± 0.2(25)	35.0 ± 0.2(36)	34.3 ± 0.5(7)	34.4 ± 0.2(31)	33.4 ± 0.4(16)
2 Months	(0)	40.3 ± 0.2(25)	40.4 ± 0.2(35)	40.4 ± 0.4(7)	40.0 ± 0.2(31)	40.0 ± 0.3(15)
4 Months	(0)	42.5 ± 0.2(25)	42.7 ± 0.2(36)	42.9 ± 0.5(6)	42.4 ± 0.2(30)	42.2 ± 0.3(15)

[1] Values are means ± S.E. Numbers in parentheses indicate number of observations per mean.

[2] Solids were fed at five months of age or later to two breast-fed and two formula-fed infants.

[3] No significant differences were found using oneway analysis of variance and Duncan's multiple range test, $p<0.05$.

Table 2-8 Breast-Fed and Formula-Fed Female Infants' Size at Birth, Two Months and Four Months of Age When Solids Were First Fed During the Second, Third or Fourth Months of Life[1-3]

	Growth When Solids Were Fed to Breast-Fed Infants			Growth When Solids Were Fed to Formula-Fed Infants		
Length (cm)	2 months	3 months	4 months	2 months	3 months	4 months
Birth	52.6 ± 0.6(2)	51.7 ± 0.5(27)	52.2 ± 0.3(45)	52.0 ± 0.6(14)	51.4 ± 0.5(31)	50.7 ± 0.5(13)
2 Months	57.9 ± 1.6(2)	58.3 ± 0.4(27)	58.3 ± 0.3(46)	57.4 ± 0.5(14)	57.5 ± 0.4(32)	57.8 ± 0.5(14)
4 Months	62.8 ± 1.7(2)	62.8 ± 0.5(27)	63.1 ± 0.3(46)	63.0 ± 0.6(14)	62.7 ± 0.4(32)	62.3 ± 0.5(14)
Weight (kg)						
Birth	3.6 ± 0.6(2)	3.3 ± 0.1(27)	3.4 ± 0.1(46)	3.4 ± 0.1(14)	3.2 ± 0.1(32)	3.0 ± 0.1(14)
2 Months	5.2 ± 0.5(2)	5.3 ± 0.1(27)	5.2 ± 0.1(46)	5.2 ± 0.2(14)	5.1 ± 0.1(32)	5.0 ± 0.2(14)
4 Months	6.0 ± 0.4(2)	6.4 ± 0.1(27)	6.4 ± 0.1(46)	6.5 ± 0.2(14)	6.4 ± 0.1(32)	6.3 ± 0.2(14)
Head Circumference (cm)						
Birth	34.9 ± 0.7(2)	33.9 ± 0.2(27)	34.2 ± 0.2(45)	34.1 ± 0.3(14)	34.0 ± 0.2(31)	33.4 ± 0.4(13)
2 Months	39.8 ± 0.7(2)	39.1 ± 0.2(26)	39.2 ± 0.2(45)	39.0 ± 0.3(13)	39.0 ± 0.2(32)	38.5 ± 0.2(13)
4 Months	41.4 ± 0.7(2)	41.1 ± 0.2(25)	41.5 ± 0.2(45)	41.4 ± 0.2(13)	41.3 ± 0.2(32)	40.9 ± 0.2(13)

[1] Values are means ± S.E. Numbers in parentheses indicate number of observations per mean.

[2] Solids were fed at five months of age or later to two breast-fed infants.

[3] No significant differences were found using oneway analysis of variance and Duncan's multiple range test, $p<0.05$.

Table 2-9 **Anthropometric Measurements of Calgary Infants at Birth and Corresponding National Center for Health Statistics Percentiles for Breast-Fed and Formula-Fed Infants**[1,2]

	Breast-Fed Infants		Formula-Fed Infants	
	Males	Females	Males	Females
Length (cm)				
Mean	52.7 ± 0.3(63)	52.0 ± 0.2 (77)	51.3 ± 0.3(56)	51.4 ± 0.3(58)
Percentile	83	90	69	81
Weight (kg)				
Mean	3.5 ± 0.1(63)	3.4 ± 0.05(78)	3.2 ± 0.1(56)	3.2 ± 0.1(60)
Percentile	66	65	44	48
Head Circumference (cm)				
Mean	34.8 ± 0.2(63)	34.1 ± 0.1 (77)	34.0 ± 0.2(56)	33.9 ± 0.2(58)
Percentile	50	44	28	38

[1] Means are values ± S.E. Numbers in parentheses indicate number of observations per Mean.

[2] Percentiles are used for assessing physical size and growth of children. Percentiles are determined by comparing means of anthropometric measurements with standardized percentile curves established by the National Center for Health Statistics in the United States. Percentiles indicating normal growth are those between 25 and 75.

percentile scores for weight and low percentile scores for head circumference. Male formula-fed infants had the lowest percentile scores for all anthropometric measurements. However, all percentiles fell between the 25^{th} and 90^{th} percentiles which is an important observation, since measurements between the 25^{th} and 75^{th} percentiles likely represent normal growth, whereas values above the 90^{th} and below the 10^{th} percentiles should first be evaluated for accuracy of measurement and recording and then assessed for the need to evaluate the child medically.

5. Infants of Smoking and Non-Smoking Mothers

Size at birth, two months and four months of age was compared for infants born to smoking and non-smoking mothers (**Table 2-10**). There were no significant differences between the groups for gestational age or length at birth. Mean birth weight of male infants born to non-smoking mothers (3.4 kg) was slightly but not significantly greater than that of their female counterparts (3.3 kg) but was signficantly different than mean birth weights of both male and female infants born to smoking mothers (3.2 kg). Mean head circumference at birth for male infants born to non-smokers (34.7 cm) was significantly different ($p<0.05$) than that of female infants of non-smoking mothers (34.0 cm) and male and female infants of smoking mothers (33.9 cm and 34.0 cm, respectively). Regardless of their mothers' smoking habits, male infants grew more rapidly than female infants in length, weight and head circumference during the first two months of life but similar rates of growth were observed for both sexes between two and four months. At four months of age, male infants from both groups were significantly larger than female infants.

Table 2-10 Size at Birth, Two Months and Four Months of Age for Infants Born to Smoking and Non-Smoking Mothers[1-3]

	Infants of Smoking Mothers		Infants of Non-Smoking Mothers	
	Males	Females	Males	Females
Gestational Age (wks)	39.8 ± 0.2 (25)	39.7 ± 0.1 (31)	39.6 ± 0.1 (82)	39.7 ± 0.1 (94)
Length (cm)				
Birth	51.7 ± 0.4 (25)	51.3 ± 0.4 (30)	52.3 ± 0.3 (82)	51.9 ± 0.2 (92)
2 months	58.5 ± 0.4^{ab}(25)	57.1 ± 0.2^{c}(31)	59.1 ± 0.2^{a}(82)	58.1 ± 0.2^{b} (94)
4 months	64.1 ± 0.4^{a} (25)	62.3 ± 0.4^{b}(31)	64.2 ± 0.2^{a}(82)	62.9 ± 0.2^{b} (94)
Weight (kg)				
Birth	3.2 ± 0.1^{a} (25)	3.2 ± 0.1^{a}(31)	3.4 ± 0.1^{b}(82)	3.3 ± 0.04^{ab}(94)
2 months	5.4 ± 0.1^{ac}(25)	5.0 ± 0.1^{b}(31)	5.7 ± 0.1^{c}(82)	5.2 ± 0.1^{ab} (94)
4 months	6.8 ± 0.1^{a} (25)	6.3 ± 0.1^{b}(31)	7.0 ± 0.1^{a}(82)	6.4 ± 0.1^{b} (94)
Head Circumference (cm)				
Birth	33.9 ± 0.2^{a} (25)	34.0 ± 0.2^{a}(30)	34.7 ± 0.2^{b}(82)	34.0 ± 0.1^{a} (92)
2 months	39.8 ± 0.2^{a} (25)	39.0 ± 0.2^{b}(30)	40.4 ± 0.1^{c}(80)	39.0 ± 0.1^{b} (93)
4 months	42.0 ± 0.2^{a} (25)	41.3 ± 0.2^{b}(30)	42.7 ± 0.1^{c}(80)	41.3 ± 0.1^{b} (93)

[1] Values are means ± S.E. Numbers in parentheses indicate number of observations per mean.

[2] Smoking is defined as any smoking during pregnancy and four months postpartum.

[3] Statistical significance is based on oneway analysis of variance and Duncan's multiple range test. Means in a row (across) with the same superscript or without superscripts are not significantly different, $p<0.05$.

Table 2-11 Gestational Age and Size at Birth for Infants Whose Mothers Smoked or Did Not Smoke During Pregnancy[1-3]

	Infants of Smoking Mothers		Infants of Non-Smoking Mothers	
	Male	Female	Male	Female
Gestational age	39.8 ± 0.2 (22)	39.7 ± 0.2 (23)	39.6 ± 0.1 (85)	39.7 ± 0.1 (102)
Birth size				
Length (cm)	51.7 ± 0.4 (22)	51.3 ± 0.5 (22)	52.2 ± 0.2 (85)	51.9 ± 0.2 (100)
Weight (kg)	3.2 ± 0.1^{a} (22)	3.3 ± 0.1^{ab} (23)	3.4 ± 0.04^{c} (35)	3.3 ± 0.04^{ab} (102)
Head Circumference (cm)	33.8 ± 0.2^{a} (22)	34.0 ± 0.3^{a} (22)	34.7 ± 0.2^{b} (85)	34.0 ± 0.1^{a} (100)

[1] Values are means ± S.E. Numbers in parentheses indicate number of observations per mean.

[2] Smoking is defined as any smoking during pregnancy.

[3] Statistical significance is based on oneway analysis of variance and Duncan's multiple range test. Means in a row (across) with the same superscript or without superscripts are not significantly different, $p<0.05$.

Eleven mothers who smoked during the first four postpartum months did not smoke during pregnancy. These mothers were categorized in the "non-smoking" group along with mothers who had never smoked "at all" (Table 2-11) to evaluate the effects of smoking during pregnancy on birth size. No significant differences were observed for gestational age or length at birth for infants of smoking or non-smoking mothers. However, mean values for weight and head circumference for male infants whose mothers smoked during pregnancy were significantly lower ($p<0.05$) than for male infants whose mothers had not smoked. For female infants, identical mean values for birth weight and head circumference were observed for infants born to smoking and non-smoking mothers.

IV. Infant Birth Size and Growth

Rates of growth in length (Fig. 2-3), weight (Fig. 2-4) and head circumference (Fig. 2-5) were similar for infants classified as small, average or large in size at birth. Infant birth weight percentiles ranging from 0 to 10, 45 to 55 and 90 to 100 were used to categorize infants as small, average or large. Male and female infants were separated to illustrate differing rates of growth. Gestational age was significantly different ($p<0.05$) for infants in these groups, with means ranging from 39.1 to 40.2 weeks. Within each of the three parameters, anthropometric measurements were significantly different ($p<0.005$) at birth, two months and four months of age.

V. Infant Birth Size and Maternal Characteristics

Comparison of mothers who delivered infants categorized by weight as small, average, or large at birth revealed that maternal height, pregravid weight and pregnancy weight gain influenced infant size at

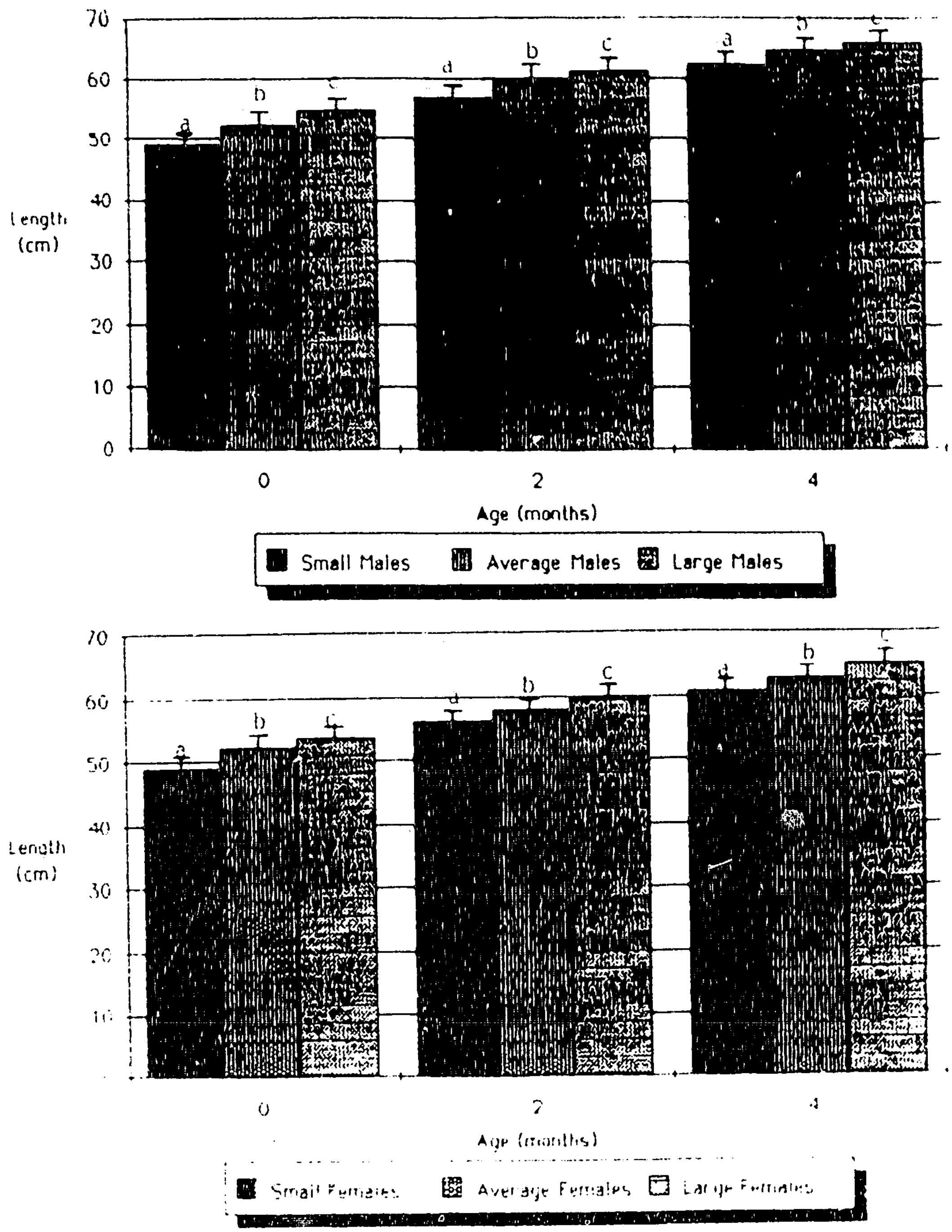

Figure 2-3 Growth in length from birth to four months of age for infants classified as small, average or large based on percentiles of weight (0-10, 45-55, 90-100) at birth

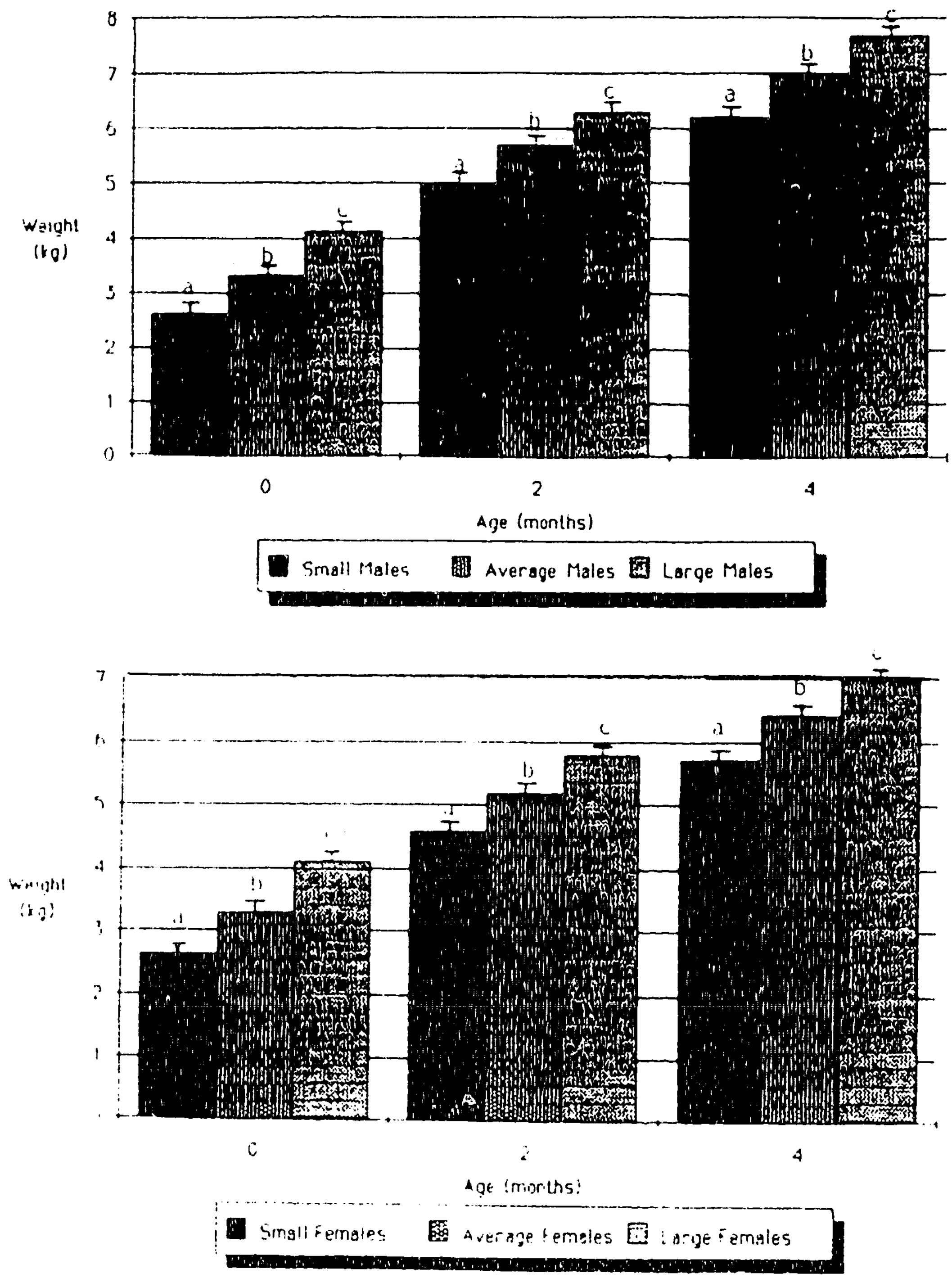

Figure 2-4 Growth in weight from birth to four months of age for infants classified as small, average or large based on percentiles of weight (0-10, 45-55, 90-100) at birth

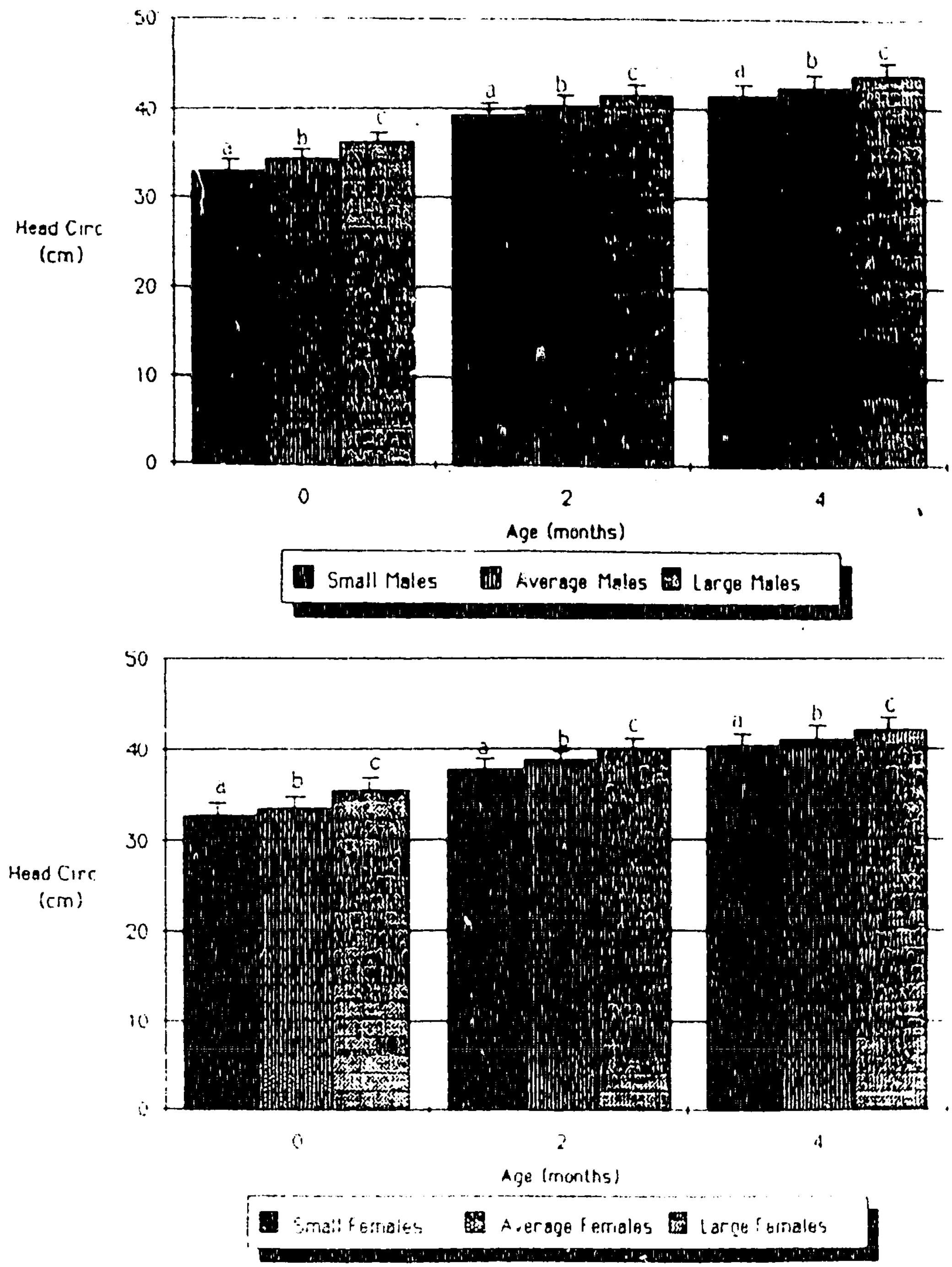

Figure 2-5 Growth in head circumference from birth to four months of age for infants classified as small, average or large based on percentiles of weight (0-10, 45-55, 90-100) at birth

birth (Table 2-12). For male infants, mean maternal age (range of means, 25.8 to 26.1 years), did not differ significantly for the three groups. Mothers who delivered small babies were shorter, lighter pregravid and lighter at parturition than mothers of average or large-sized babies, but statistical significance was only reached for weight and weight gain when mothers of small and large babies were compared. Mean height of mothers who delivered small male babies was significantly different than mean height of mothers of either average or large-sized babies. For female infants, mothers who delivered small babies were lighter pregravid and lighter at parturition than mothers of average or large-sized infants, but differences were significant only when mothers of small and large babies were compared. No significant differences in mean height were observed; mothers who delivered small babies were slightly taller than mothers from other groups. In all three groups, pregravid weight and pregnancy weight gain were higher for mothers of female than male infants. Why this is so is not clear, since both male and female groups were divided according to size in the same way using percentiles 0-10, 45-55 and 90 to 100 to establish groups of small, average and large-sized infants.

The Weight for Height Ratio Index was highest for mothers of average or large-sized female infants. The ratio for mothers of small, average and large infants, calulated as maternal [Wt.(kg)] x $[Ht.(cm)^2]^{-1}$x100), was 0.21, 0.20, and 0.22 for mothers of male infants and 0.20, 0.23, and 0.24 for mothers of female infants, respectively.

Table 2-12 Age, Height, Pregravid Weight, Pregnancy Weight Gain and Weight for Height Ratio Index for Mothers Who Delivered Small, Average or Large Infants[1-4]

	Infant Size at Birth		
	Small	Average	Large
Mothers of Male Infants			
Age of mothers (yr)	26.1 ± 0.9 (12)	25.9 ± 1.2 (13)	25.8 ± 0.7 (13)
Height (cm)	157.2 ± 3.0^{a}(12)	164.9 ± 1.5^{b} (13)	165.8 ± 2.7^{b}(13)
Pregravid weight (kg)	51.9 ± 3.5^{a}(12)	54.8 ± 1.1^{ab}(13)	60.8 ± 2.2^{b}(13)
Pregnancy weight gain (kg)	12.1 ± 0.7^{a}(12)	14.6 ± 1.5^{ab}(13)	16.9 ± 1.6^{b}(13)
Weight Height Ratio Index	0.21 ± 0.01(12)	0.20 ± 0.01 (13)	0.22 ± 0.01(13)
Mothers of Female Infants			
Age of mothers (yr)	27.2 ± 1.3^{ab}(14)	25.0 ± 1.1^{a} (13)	28.4 ± 0.9^{b}(15)
Height (cm)	162.4 ± 1.4 (14)	160.2 ± 2.3 (13)	161.3 ± 3.4 (15)
Pregravid weight (kg)	52.9 ± 1.5^{a} (13)	59.9 ± 3.2^{ab}(13)	62.6 ± 2.3^{b}(15)
Pregnancy weight gain (kg)	13.0 ± 1.5^{a} (14)	15.6 ± 1.5^{ab}(13)	18.1 ± 1.3^{b}(15)
Weight Height Ratio Index	0.20 ± 0.01 (12)	0.23 ± 0.01 (13)	0.24 ± 0.01(15)

1 Infant weight percentiles at birth (0-10, 45-55, 90-100th percentiles) were used to categorize infants as small, average or large.

2 Values are means $\pm$ S.E. Numbers in parentheses indicate number of observations per mean.

3 Weight for Height Ratio Index equals [Wt. (kg)] x [Ht. (cm)^2]$^{-1}$ x 100.

4 Statistical significance is based on oneway analysis of variance and Duncan's multiple range test. Means in a row (across) with the same superscript or without superscripts are not significantly different, $p<0.05$.

VI. Maternal Weight Changes Postpartum and Infant Growth

To examine the effects of postpartum maternal weight loss on lactational outcome and early infant growth, the breast-feeding group was separated from the formula-feeding group for analysis. For the breast-feeding group, infant weight gain was not significantly affected by maternal weight gain, loss or maintainance either during the first two months or from two to four months postpartum (Table 2-13). All infants gained weight during the first four months of life, although female infants on average gained slightly less than male babies. Because of the differences in growth rates, male and female infants were separated within the breast-fed group. From birth to two months of age, mean weight gain ranged from 2.3 to 2.4 kg (5.1 to 5.3 lb) for male infants and from 1.9 to 2.0 kg (4.2 to 4.4 lb) for female infants, regardless of postpartum maternal weight changes. Similarly, from two to four months of age, mean weight gain ranged from 1.0 to 1.3 kg (2.2 to 2.9 lb) for male infants and from 0.9 to 1.0 kg (2.0 to 2.2 lb) for female infants. Most women lost weight postpartum; 78% of women surveyed lost weight between parturition and two months postpartum whereas 67% lost weight between two and four months postpartum. The average loss ranged from 4.3 to 4.7 kg (approximately 9.5 to 10 lb) during the first four postpartum months.

Table 2-13 Corresponding Maternal and Infant Weight Changes in the Breast-Feeding Group at Two and Four Months Postpartum[1-4]

	Maternal Wt. Gain		Maternal Wt. - No Change		Maternal Wt. Loss	
Male Infants	Maternal Wt.	Infant Wt.	Maternal Wt.	Infant Wt.	Maternal Wt.	Infant Wt.
2 months	+1.7 ± 0.6(6)	+2.3 ± 0.1(6)	0.0 (6)	+2.4 ± 0.2 (6)	-2.4 ± 0.3(35)	+2.3 ± 0.1 (35)
4 months	+1.4 ± 0.5(6)	+1.0 ± 0.1(6)	0.0 (9)	+1.3 ± 0.1 (9)	-1.9 ± 0.2(35)	+1.3 ± 0.1 (35)
Female Infants						
2 months	+1.8 ± 0.6(8)	+2.0 ± 0.1(8)	0.0 (5)	+1.9 ± 0.2 (5)	-2.7 ± 0.3(53)	+1.9 ± 0.1 (53)
4 months	+2.1 ± 0.8(6)	+0.9 ± 0.1(6)	0.0(17)	+1.1 ± 0.1(17)	-2.0 ± 0.2(43)	+1.1 ± 0.04(43)

[1] Values are means ± S.E. Numbers in parentheses indicate number of observations per mean.

[2] Weight changes were calculated as follows:

Mothers: Weight at 2 months = Wt. (2 month Clinic visit) - Wt. (Home Visit).

Weight at 4 months = Wt. (4 month Clinic visit) - Wt. (2 month Clinic visit).

Infants: Weight at 2 months = Wt. (2 month Clinic visit) - Wt. (Birth).

Weight at 4 months = Wt. (4 month Clinic visit) - Wt. (2 month Clinic visit).

[3] No significant correlation between infant growth and maternal weight changes at either two months or four months postpartum was found using [illegible]son correlation coefficients.

[4] At 2 months overall mean mate[illegible]al weight change was -1.8 ± 0.2 kg (n=113); mean infant weight change was +2.1 ± 0.04 kg (n=113), correlation coefficient was -.0061 (NS). At 4 months overall mean maternal weight change was -1.1 ± 0.2 kg (n=116); mean infant weight change was +1.2 ± 0.03 kg (n=116), correlation coefficient was -.0336 (NS).

The relationship between weight gain in a combined group of male and female breast-fed infants and weight loss in their mothers was examined. Infant weight gain was divided into deciles for the periods from birth to two months (Table 2-14) and two to four months (Table 2-15). From birth to two months postpartum, infant weight gain ranged from 1.1 to 3.4 kg (2.5 to 7.4 lb). Mean maternal weight loss corresponding to deciles of infant weight gain during the first two months ranged from 1.2 to 2.8 kg (2.6 to 6.2 lb). From two months to four months postpartum, infant weight gain ranged from 0.2 to 2.4 kg (0.4 to 5.3 lb) whereas corresponding mean maternal weight loss ranged from 0.6 to 1.8 kg (1.3 to 4.0 lb). No correlations between infant weight gain and maternal weight loss were observed from birth to two months or from two to four months postpartum.

VII. Impact of Maternal Characteristics on Infant Birth Weight and Growth

A stepwise multiple regression procedure was used to determine correlations between various maternal characteristics and infant birth weight. Maternal pregravid weight was found to have the greatest effect on infant birth weight ($r=0.28$) followed by length of gestation ($r=0.27$), weight gain during pregnancy ($r=0.24$) and maternal age ($r=0.10$). There was no correlation between maternal height and infant birth weight. To evaluate effects of maternal characteristics and infant weight at birth on infant growth during the first four months of life, a second stepwise multiple regression procedure was conducted. However, when maternal height, metabolic pregravid weight (weight $^{0.75}$), pregnancy weight gain, age, length of gestation, and infant weight at birth were correlated with infant weight gain from birth to four months, only maternal age was significant, by an inverse correlation (r=-0.16, p=0.03).

Table 2-14 Relationship Between Weight Gain in Male and Female Breast-Fed Infants and Weight Loss in Their Mothers Between Birth and Two Months Postpartum[1-3]

Deciles	Infant Weight Gain (kg)	Maternal Weight Loss (kg)
0-10	1.4 ± 0.03(10)	-2.1 ± 0.6(10)
11-20	1.6 ± 0.01(13)	-2.8 ± 0.5(13)
21-30	1.7 ± 0.02(10)	-1.6 ± 0.5(10)
31-40	1.8 ± 0.01(13)	-1.6 ± 0.6(13)
41-50	2.0 ± 0.01(14)	-1.3 ± 0.8(14)
51-60	2.1 ± 0.02(12)	-1.2 ± 0.5(12)
61-70	2.2 ± 0.01(11)	-2.0 ± 0.5(11)
71-80	2.4 ± 0.01(12)	-1.2 ± 0.8(12)
81-90	2.7 ± 0.04 (8)	-2.2 ± 0.7 (8)
91-100	3.0 ± 0.03(10)	-2.5 ± 0.6(10)

1 Values are means ± S.E. Numbers in parentheses indicate number of observations per mean.

2 Infants were divided into ten groups according to weight gain during the first two months of life to facilitate comparison of infant and maternal weight changes.

3 No significant differences were found using Pearson correlation coefficients, $p<0.05$.

Table 2-15 Relationship Between Weight Gain in Male and Female Breast-Fed Infants and Weight Loss in Their Mothers Between Two and Four Months Postpartum[1-3]

Deciles	Infant Weight Gain (kg)	Maternal Weight Loss (kg)
0-10	0.6 ± 0.10(10)	-1.1 ± 1.0(10)
11-20	0.8 ± 0.01(13)	-1.1 ± 0.3(13)
21-30	0.9 ± 0.01(15)	-0.6 ± 0.4(15)
31-40	1.0 ± 0.01 (9)	-1.6 ± 0.7 (9)
41-50	1.1 ± 0.01(13)	-1.1 ± 0.4(13)
51-60	1.2 ± 0.01(11)	-1.8 ± 0.5(11)
61-70	1.3 ± 0.01(11)	-1.1 ± 0.5(11)
71-80	1.4 ± 0.02(14)	-0.7 ± 0.4(14)
81-90	1.6 ± 0.02(11)	-1.5 ± 0.5(11)
91-100	1.9 ± 0.10 (9)	-1.1 ± 0.3 (9)

[1] Values are Means ± S.E. Numbers in parentheses indicate number of observations per Mean.

[2] Infants were divided into ten groups according to weight gain between two and four months of life to facilitate comparison of infant and maternal weight changes.

[3] No significant differences were found using Pearson correlation coefficients, $p<0.05$.

D. DISCUSSION

I. Description of Sample

The acquisition of infant subjects who were exclusively formula-fed from the first week of life to four months of age progressed more slowly than the acquisition of exclusively breast-fed subjects. This is not surprising since a recent Canadian survey reported that 75% of mothers breast-feed their infants in hospital and 62% continue to breast-feed at two months post-partum (McNally et al. 1985). In Calgary during 1984, 49% of infants were exclusively breast-fed during the first week home following hospital discharge after birth whereas only 25% of infants were exclusively formula-fed at that time (Walker et al. 1987). Since approximately 30% of formula-fed babies are switched to cow's milk by three to four months of age (Canada. Department of Health & Welfare, 1985), short duration of formula-feeding may have excluded some infants from the study. Furthermore, formula-fed infants tend to receive their first solid foods earlier than breast-fed infants (Myres, 1979), and it was noted by the investigator that several formula-fed infants did, in fact, receive solids prior to two months of age, causing the exclusion of those infants from the study.

Although the birth rate is slightly higher for male than for female infants (Canada. Minister of Supply & Services, 1986), our sample retained 119 male and 138 female subjects. Because male infants may require more milk (Pao et al. 1980) or may be unsatisfied with breast milk alone, there might be a greater tendency for mothers to supplement breast-fed male infants with formula or introduce solids during the first one to two months of life. A previous study indicated that in 1984, 33% of male infants and 25% of female infants were given solids during the first and second months of life (Walker et al. 1987). Since any formula supplementation after the first week home or provision of solids before two months were reason for exclusion, both factors may have resulted in the sex distribution observed in the present study.

All of the eleven Community Health Clinics in Calgary contributed varying numbers of breast-fed or formula-fed infant subjects for the study. Since method and duration of infant feeding may be affected by factors such as parity (Forman et al. 1985), education (Myres, 1979), receipt of formula gift packs, income, first language of the mother, influence of relatives, friends, family, hospital staff, prenatal class education, La Leche League, books and publications (Canada, Health & Welfare 1982) as well as maternal age (Fieldhouse, 1984, Hally et al. 1984), the distribution of subjects by clinic tends to reflect some of the socio-demographic features of the community surrounding the health clinics. The identification of clinics which present predominantly formula-fed subjects may be useful in determining education strategies or specific needs of the community serviced by a particular clinic. For example, the Downtown clinic in Calgary serves a low-income population consisting of a relatively large proportion of Vietnamese people. Culturally, the Vietnamese tend to choose formula-feeding, but if educational materials were available in their own language or if an interpreter was available in the clinic, an opportunity to discuss alternative methods of infant feeding may arise. In addition, low-income groups may be the ones to benefit most from the cost-saving and immunological features of breast-feeding compared with formula-feeding.

Various ethnic groups were represented among the infants and mothers comprising the study sample. It was conceivable that a greater proportion of the formula-fed infants came from Asian or Oriental heritage than from Caucasian backgrounds, but without systematic recording of ethnicity it was impossible to determine the proportion of ethnic groups within either of the breast-fed or formula-fed groups. Other investigators have reported that African, Chinese, Indian (Hytten & Chamberlain, 1980), Black (Rosso, 1985), Hispanic and Asian women (Shiono et al. 1986a) have babies of lower average birth weight than Whites, even after adjustments have been made for maternal and environmental variables. Ethnicity may account for a difference in birth weight by 300 to 400 grams (Hytten & Chamberlain, 1980). To some extent, one would expect a greater effect with new immigrants than with second or third generation families, but whether ethnicity affects feeding patterns, infant birth weight or growth in this population has not been established.

Since many of the mothers were unhappy with questions about their weight, and some women refused to participate in the study, some self-selection of respondents occurred. Although this may have skewed results, the extent of the effect is unknown. Furthermore, although some concern about the accuracy of self-reported weights may be justified, a report by Stunkard and Albaum (1981) provides assurance that self-reported weights are indeed valid. In their study, reported weights were compared with measured weights for slightly more than 1300 subjects in the United States and Denmark. The American component of the study included 550 subjects; 19% men and 81% women, with a mean age of 40.0 ± 0.6 (SE) years, whereas the Danish component included 752 subjects; 79% men and 21% women. The American subjects, even those who were obese, were remarkably accurate in their reporting, resulting in a correlation coefficient close to one comparing reported and measured weights. Although the Danish subjects, particularly women over age 40, were somewhat less accurate than the Americans in their reporting, another study by Pirie et al. (1981) supports the belief that self-reported weights in the United States are useful. Pirie and her colleagues devised equations to predict measured weight from reported weight, based on a study of more than 3400 subjects' data (1610 men, 1799 women; white, aged 20 to 59 years) collected by the Lipid Research Clinics Program Prevalence Study in Minnesota. Different equations were used for men and women since women in all weight categories tended to understate their weights, while in general, heavy men tended to understate while lower weight men tended to overstate their body weights. For women in the 20 to 39 year age group, the amount of discrepancy between measured and reported weights increased as their degree of overweight increased. The linear regression equations for predicting measured weights were "measured weight (lb) = [1.03 x reported weight (lb)] - 3.79" for men and "measured weight (lb) = [1.10 x reported weight (lb)] - 8.80" for women (Pirie et al., 1981). Using these equations, R^2 was highly significant; 0.92 for men and 0.94 for women. Although no large Canadian studies comparing self-reported with measured weights are currently available, it is likely that Canadian subjects in the present study are more similar to Americans than to Danes, and the concept of using self-reported weights is valid. As Stunkard and

Albaum (1981) aptly state, "measurement of body weight is often not feasible for financial and/or logistical reasons" but the skepticism traditionally directed towards the validity of self-reported weights is not justified. It is possible that a larger amount of error may have been present in the self-reported weights of women during the early postpartum period. Ideally, a sub study comparing self-reported with actual body weights in this population would have been conducted to quantify the variance.

II. Mothers' Profile

1. Breast-Feeding and Formula-Feeding Mothers

It was not surprising that breast-feeding mothers were older (26.9 vs. 25.7 yrs) than formula-feeding mothers, since this trend has been reported previously by a number of investigators (Committee on Breastfeeding, Manitoba Pediatric Society, 1982, Fieldhouse, 1984, Hally et al. 1984, Walker et al. 1987). Forman et al. (1985) showed that the prevalence of breast-feeding is highest in the 25-34 year old age group and that breast-feeding rates increase slightly with age within the 25-39 year age group. Nevertheless, it was interesting that in the present study the trend for breast-feeding mothers to be older was maintained even though women under the age of twenty, who tend to formula-feed, were excluded.

The similarity between the breast-feeding and formula-feeding groups for maternal height, pregravid weight, weight gain during pregnancy and length of gestation facilitated easy comparison of infant birth size and growth during the first few months of life. Size of maternal subjects was similar to that reported for pregnant women in Glasgow, Scotland (Durnin et al. 1985, Durnin, 1987) and weight for height based on means was within the ideal range (Metropolitan Life Foundation, 1983). Mean weight gains during pregnancy, 14.6 kg (32 lb) in the breast-feeding group and 15.0 kg (33 lb) in the formula-feeding group, were comparable to the 14.7 $\pm$ 4.2 kg (32 $\pm$ 9 lb) mean gain measured by Blackburn and Calloway (1985) but greater than the 10.8 to 12.5 kg (24 to 28 lb) mean gains measured by Durnin et al. (1985). Mean weights postpartum were similar to those reported by Butte et al. (1984) and Quandt (1983) for lactating women (Table 2-16). The observation that neither breast-feeding nor formula-feeding mothers had resumed their former pregravid weight is also in agreement with findings by Butte et al. (1984) and Quandt (1983), although their studies included only breast-feeding subjects. Naismith and Ritchie (1975) reported a similar rate of weight loss comparing breast-feeding and bottle-feeding mothers up to three months postpartum, even though the breast-feeding group was consuming an average of nearly 900 kcal/day more than the bottle-feeding mothers. This is surprising since the energy cost of milk production is approximately 700 kcal/day. Breast-feeding women are encouraged to increase their food consumption during lactation to provide an additional 450 kcal/day above their pre-pregnant requirements (Canada. Department of Health & Welfare, 1987). Thus, weight loss of lactating women over a four month period may be less than that observed for formula-feeding women who may choose to restrict caloric intake to effectively induce weight loss.

Table 2-16 Comparison of Mean Maternal Weights During the First Four Postpartum Months[1]

	Postpartum	Two Months	Four Months
Breast-Feeding	63.1 ± 0.7	61.2 ± 0.7	60.5 ± 0.7
Formula-Feeding	63.6 ± 1.2	62.1 ± 1.3	60.4 ± 1.2
Butte et al. (1984)	64.6 ± 1.4	60.7 ± 1.5	59.3 ± 1.7
Quandt (1983)	63.4 ± 1.3	61.9 ± 1.3	60.4 ± 1.3

[1] Values are means ± SE.

2. Smoking and Non-Smoking Mothers

The increased prevalence of smoking among formula-feeding mothers has been reported previously (Yeung et al. 1981a, Goodine and Fried, 1984, Walker et al. 1987). It is well known that non-smokers are more likely to initiate breast-feeding and to continue breast-feeding for a longer duration (Goodine and Fried, 1984). It is also encouraging that many mothers stopped or reduced smoking after they learned they were pregnant, and that only 12% of breast-feeding mothers in this population were smoking during pregnancy and four months postpartum.

Previous studies (Grigsby Harrison et al. 1983; Picone et al. 1982a) have reported that women who smoke have lower pregravid weight and pregnancy weight gain than non-smokers, in spite of evidence that smokers actually consume more calories. In the present study, no effect of smoking on pregravid weight was observed, but mothers who smoked gained slightly but not significantly more weight than those who did not smoke. Another interesting trend, although not statistically significant, was that non-smokers lost slightly more weight than smokers in the first four postpartum months. As this trend has not been reported elsewhere, additional study is needed to further explore this finding; the difference may have been related to a higher incidence of breast-feeding among non-smokers. In agreement with a recent report by Spady et al. (1986), mothers who smoked were significantly younger than non-smoking mothers.

Unfortunately, in the present study, smoking data was missing for nearly 10% of subjects. An error in the original "Study of Infant Weight Gain" form used for data collection was responsible, in part, for missing data. Boxes to indicate answers of "Yes" or "No" for maternal smoking habits were included on the form corresponding to times of the "home visit", "2 month" and "4 month" clinic visits, but not corresponding to "during pregnancy." Consequently, nurses recording data on the "Study of Infant Weight Gain" form quite often omitted recording smoking habits during pregnancy. After the error on the form was discovered, the format of the form was corrected.

III. Infants' Profile

1. Infant Birth Weight

Average birth weights for infant subjects, 3.4 kg (7.4 lb) for males and 3.3 kg (7.2 lb) for females, were slightly higher than mean weights of reference infants in the United States. There, the National Center for Health Statistics has established that mean birth weights for male and female infants are 3.3 and 3.2 kg, respectively (Hamill et al., 1979).

A comparison of infant birth weights by percentiles with National Center for Health Statistics' percentiles indicated considerable similarities between the two groups (Table 2-17). In the present study, female infants were slightly heavier at each percentile and male infants were slightly heavier from the 25th to 95th percentiles, inclusive, compared with National Center for Health Statistics references. The reasons why the Calgary infants were slightly heavier are not clear, but may be due to differences in ethnicity, nutrition or other factors.

Table 2-17 Birth Weights for Calgary Subjects and National Center for Health Statistics Reference Infants, by Percentiles

	Calgary Subjects Weight (kg)		NCHS Reference Infants Weight (kg)	
Percentiles	Males	Females	Males	Females
5	2.6	2.6	2.6	2.4
10	2.7	2.7	2.8	2.6
25	3.1	3.0	3.0	2.9
50	3.4	3.3	3.3	3.2
75	3.7	3.6	3.6	3.5
90	3.9	3.9	3.8	3.6
95	4.1	4.1	4.2	3.8

Significant differences in birth weight were observed according to gestational age. Forty-six percent of male infants and 52% of female infants were delivered at 40 weeks gestation. Mean birth weight at 40 weeks gestation was 3464 g for male infants and 3395 g for female infants; weights which were very similar to the weight of a reference fetus, 3450 g, reported by Ziegler et al. (1976). In the present study, birth weight was reduced in male and female infants, respectively, by 220 and 234 g at 39 weeks and by a further 179 and 49 g at 38 weeks gestation. Ziegler et al. (1976) reported a reduction in birth weight of 170 g at 39 weeks and a further decrease of 120 g at 38 weeks gestation. The lower birth weights observed at 38 and 39 weeks gestation were expected since gestational age is the most significant variable determining size at birth (Schell & Hodges, 1985). Fat accretion occurs from 28 weeks (Grigsby Harrison et al. 1983) to term, and fetal body composition changes within short time intervals of a week or less. However, reduced birth weight at 41 weeks was also observed in both male (-1 g, n=21) and female (-41 g, n=16) infants, but this may represent random variation since the reduction in birth weight was small.

Mean weight at birth for the six low-birth-weight infants (2438 g) fell below the fifth percentile for the study population and was approximately 750 g lower than the mean birth weight for infants of similar gestational age. For the low-birth-weight group, mean maternal height, pregravid weight and pregnancy weight gain were all markedly lower than means for both the breast-feeding and formula-feeding groups. Most of the low-birth-weight infants were formula-fed, in agreement with results published by others (Yeung et al. 1981b; Goodine & Fried, 1984; Barros, 1986); three of the six infants were believed to be Oriental, judging by names of their parents. Small babies are less likely to be breast-fed due to difficulties in sucking during the first few days of life (Hytten and Leitch, 1971) and separation from their mothers (Elander & Lindberg, 1984).

Pregravid weight of mothers of low-birth-weight infants was 11.8 kg lower and pregnancy weight gain was nearly 5 kg lower than for the formula-feeding group. Low weight gain during pregnancy (15 lbs. or less) has been associated with shorter gestations (0.5 wk) and smaller placentas as well as reduced birth weight (Picone et al. 1982b). Hytten and Chamberlain (1980) caution that although women who gain little weight have smaller babies, a pattern of poor reproduction rather than a causal relationship may be responsible.

Low-birth-weight infants are considered to be at increased risk for morbidity and mortality (Behrman, 1985). Anthropometric measurements below the 25th percentile and certainly below the 10th percentile are cause for further evaluation of the infant's health status (Hamill et al. 1979). Identification of mothers of low-birth-weight infants may well be an important function of community-based health care professionals, since they play an important role in targeting nutrition education programs to high-risk segments of the population. In addition to the immediate needs of the low-birth-weight infant and his mother, planning for future siblings may need to include nutrition education since birth weights of siblings tend to be very similar.

2. **Breast-Fed and Formula-Fed Infants**

Birth size and subsequent growth patterns for breast-fed and formula-fed infants within a population are of particular interest since varying results are reported elsewhere (Ahn and MacLean, 1980; Ferris et al. 1980; Czajka-Narins and Jung, 1986). By definition, breast-feeding in other studies frequently includes some formula supplementation, whereas in the present study, only exclusive breast-feeding was permitted. Populations in the United States or in other centres in Canada may also present different results due to variations in ethnicity, socioeconomic status, education and other factors.

In the present study, birth length, weight and head circumference were lower in formula-fed infants than in breast-fed males. However, formula-fed males grew at a faster rate than breast-fed males in length and head circumference during the first four months of life. Female infants from both the breast-fed and formula-fed groups grew at similar rates. The comparable rate of weight gain in the breast-fed and formula-fed groups may be one indicator of successful lactation in this population.

Females infants were smaller at birth and remained smaller than male infants during the first four months of life. This finding is in agreement with National Center for Health Statistics reference standards (Hamill et al. 1979).

3. Introduction of Solid Foods

Mean ages at which solid foods were first fed to breast-fed and formula-fed infants were similar to published results from a previous study conducted in Calgary during 1984 (Walker et al. 1987).

Formula-fed infants are commonly fed solids at an earlier age than are breast-fed infants (Yeung et al. 1979, 1981a; Canada. Department of Health and Welfare, 1985) but current trends in Calgary indicate that solids are first fed at a somewhat later age than was the case a decade ago (Myres, 1979; Sarett et al., 1983). In the present study, female infants first fed solids at two months of age were slightly heavier at birth compared with those fed solids at a later age, but this trend was not observed with male infants. The pattern of solids introduction did not appear to affect growth in length, weight or head circumference during the first four months. Furthermore, it is apparent that lactating mothers continued with exclusive breast-feeding during that time, without seemingly adverse affect on their lactational success.

4. Comparison of Infant Birth Size with NCHS Percentiles

In the present study, mean values for male and female breast-fed and formula-fed infants' weight at birth ranged from the 44th to the 66th percentile compared with National Center for Health Statistics (NCHS) reference standards (Hamill et al. 1979). Although measurements of infant weight as well as length and head circumference obtained in the community health clinics were not well standardized, percentile values for the study sample nevertheless fell between the 25th and 90th percentiles, indicating normal growth according to established standards (Hamill et al. 1979).

5. Infants of Smoking and Non-Smoking Mothers

Weight at birth was reduced by an average of 100-200 grams for infants of smoking mothers. The reduction was statistically significant ($p<0.05$) for male but not for female infants. Other investigators have reported larger reductions in birth weight related to maternal smoking habits (Grigsby Harrison et al. 1983; Spady et al. 1986) with a dose-related effect (Grigsby Harrison et al. 1983). Since smoking was not quantified in the present study, a dose response cannot be confirmed, but it was noted that many smoking mothers decreased smoking while others stopped smoking during pregnancy.

Length of infants born to smoking mothers was not reduced, unlike results reported by Schell and Hodges (1985) and Spady et al. (1986). Similarly, no reductions in head circumference were observed whereas Spady et al. (1986) determined that head circumference was reduced from 35.4 to 34.8 cm ($p<0.05$) in infants of smoking mothers. It is conceivable that no differences in length and head circumference were found in the present study due to lack of standardization in technique for measuring those parameters, or perhaps higher doses of smoking are required before infant length and head circumference are affected. Schell and Hodges (1985) suggested that reductions in birth length appear to be related to decreased birth weight and may only be apparent at the highest dose level of smoking.

IV. Infant Birth Size and Growth

The concept of catch-up growth by infants born small for gestational age has been discussed elsewhere (Rowland, 1985; Bhatia et al. 1983). However, in the present study, infants classified as small, average or large in size according to weight at birth showed similar absolute rates of growth during the first four months of life. On a relative basis, some catch up growth may have occurred. According to weight at birth, infants within the tenth percentile displayed similar growth in length, weight and head circumference compared to infants in the 45^{th} to 55^{th} percentiles and infants above the 90^{th} percentiles. Thus no catch-up growth was observed for the smallest babies in this population, and conversely, no slowing in the growth rate was demonstrated for the largest babies.

V. Infant Birth Size and Maternal Characteristics

The relationship between maternal size and infant size at birth has been well established (Hytten and Chamberlain, 1980). Thus it is not surprising that maternal height, pregravid weight and pregnancy weight gain were positively related with infant weight at birth for small, average and large-sized babies. This maternal/infant relationship was evidenced by differences in the maternal Weight for Height Ratio Index, since mothers with a lower index gave birth to smaller babies. However, it appears that pregravid weight and pregnancy weight gain are more significant than maternal height. The importance of adequate weight gain during pregnancy has been strongly emphasized to promote fetal growth and to prepare the mother for lactation, as well as to protect the health of the fetus and newborn since size at birth is a reflection of health status and in part, determines postnatal growth. Certainly, efforts to educate prospective mothers regarding the importance of appropriate weight gain during pregnancy continue to be important, especially given the consideration of our weight conscious society.

VI. Maternal Weight Changes Postpartum and Infant Growth

Maternal energy stores (Hytten and Chamberlain, 1980) and diet (Ferris and Jensen, 1984; Butte et al. 1984) affect lactational outcome. Manning-Dalton and Allen (1983) studied well-nourished lactating women during the first three months postpartum and reported that those women who lost the smallest amount of weight and consumed the greatest amount of calories exhibited a positive lactational response. Ferris and Jensen (1984) suggested that women who restrict food intake while lactating have difficulty maintaining lactation and that maternal energy intakes less than 1200 kcal/day have been associated with reduced milk output. In the present study, no effects of maternal weight changes postpartum on infant weight gain were observed for the duration of the four month study period. In particular, maternal weight loss postpartum did not diminish the rate of growth in exclusively breast-fed infants, even when weight changes postpartum were evaluated in several different ways. Maternal weight changes postpartum were divided into deciles of weight loss, weight maintenance, and weight gain and compared with infant growth. Similarly, infant weight gain during the first four months of life was divided into deciles and compared with maternal weight changes. Pregravid maternal metabolic weight (calculated as [$weight^{0.75}$]) was also compared with weight loss postpartum to evaluate the effects of relative weight and weight loss on infant growth. None of the calculations indicated a significant effect of maternal weight change postpartum on lactation outcome when lactational success was measured in terms of infant weight gain.

VII. Impact of Maternal Characteristics on Infant Birth Weight and Growth

The finding that maternal pregravid weight and pregnancy weight gain are strongly associated with infant weight at birth has been previously reported by Garn and Pesick (1982). However, contrary to results reported by Hytten and Chamberlain (1980), maternal height in this study did not influence infant birth weight. The effects of maternal age on birth weight have previously been reported by Behrman (1985), and the association between length of gestation and birth weight has been well documented (Ziegler et al. 1976; Schell & Hodges, 1985). It is interesting to note that in the present study, length of gestation had a slightly stronger correlation with infant birth weight than pregnancy weight gain, even though length of gestation for subjects was an established criterion limited to 38-41 weeks.

Maternal age was inversely correlated with infant growth during the first four months of life. This finding may reflect variability of breast-milk composition and particularly a reduced content of milk lipids in older women, since Prentice (1985) found that milk lipids are higher in women under age 30. A reduction in the content of milk lipids would likely result in the slower rate of growth observed. An examination of breast-milk composition in the Calgary population would be needed to confirm this suggestion, since Prentice conducted most of her work in underdeveloped countries. The absence of any correlations between maternal height, weight, pregnancy weight gain, length of gestation, infant weight at birth and infant growth during the first four months of life is perhaps encouraging from the point of view that few factors seem to physiologically inhibit successful lactation.

REFERENCES

AHN, C.H., MACLEAN, W.C. Growth of the exclusively breast-fed infant. Am. J. Clin. Nutr. 33: 183-192, 1980.

BARROS, F.C., VICTORA, C.G., VAUGHAN, J.P., SMITH, P.G. Birth weight and duration of breast-feeding: are the beneficial effects of human milk being overestimated? Pediatr. 78 (4): 656-661, 1986.

BEHRMAN, R.E. Preventing low birth weight: a pediatric perspective. J. Pediatr 107(6): 842-854, 1985.

BHATIA, B.D., AGARWAL, D.K., AGARWAL, K.N. Exterogestate growth: relationship with maternal body size and dietary intakes. Indian J. Pediat. 50: 241-246, 1983.

BLACKBURN, M.W., CALLOWAY, D.H. Heart rate and energy expenditure of pregnant and lactating women. Am. J. Clin. Nutr. 42 (6): 1161-1169, 1985.

BUTTE, N.F., GARZA, C., STUFF, J.E., O'BRIAN SMITH, E., NICHOLS B. L. Effect of maternal diet and body composition on lactational performance. Am. J. Clin. Nutr. 39: 296-306, 1984.

CANADA. MINISTER OF SUPPLY AND SERVICES. Vital Statistics, Births and deaths. Statistics Canada Vol 1: 30-31, 1986.

CANADA. DEPARTMENT OF HEALTH AND WELFARE. Canadian infant feeding patterns: results of a national survey, 1982. Ottawa, 1985.

CANADA. DEPARTMENT OF NATIONAL HEALTH AND WELFARE. Nutrition in pregnancy - National Guidelines. Ottawa, 1987.

CZAJKA-NARINS, D.M., JUNG, E. Physical growth of breast-fed and formula-fed infants from birth to age two years. Nutr. Res. 6: 753-762, 1986.

COMMITTEE ON BREAST-FEEDING, MANITOBA PEDIATRIC SOCIETY. Breast-feeding promotion in Manitoba. C.M.A. Journal 126: 639-642, 1982.

DURNIN J.V.G.A., GRANT, S., MCKILLOP, F.M., FITZGERALD, G. Is nutritional status endangered by virtually no extra intake during pregnancy? Lancet, October 12: 823-825, 1985.

DURNIN, J.V.G.A. Energy requirements of pregnancy: an integration of the longitudinal data from the five-country study. Lancet, November 14: 1131-1133, 1987.

ELANDER, G., LINDBERG, T. Short mother-infant separation during first week of life influences the duration of breastfeeding. Acta Paediatr Scand 73: 237-240, 1984.

FERRIS, A.G., LAUS, M.J., HOSMER, D.W., BEAL, V.A. The effect of diet on weight gain in infancy. Am. J. Clin. Nutr. 33: 2635-2642, 1980.

FERRIS, A.M., JENSEN, R.G. Lipids in Human Milk: A review. 2. Composition and fat-soluble vitamins. J. Ped. Gastroenterol. & Nutr. 3 (1): 108-122, 1984.

FIELDHOUSE, P. A revival in breast-feeding. Can. J. Public health 75: 128-132, 1984.

FORMAN, M.R., FETTERLY, K., GRAUBARD, B.I., WOOTON, K.G. Exclusive breast-feeding of newborns among married women in the United States: the National Natality Surveys of 1969 and 1980. Am. J. Clin. Nutr. 42: 864-869, 1985.

GARN, S.M., PESICK, S.D. Relationship between various maternal body mass measures and size of the newborn. Am. J. Clin. Nutr. 36: 664-668, 1982.

GOODINE, L.A., FRIED, P.A. Infant feeding practices: Pre- and postnatal factors affecting choice of method and the duration of breastfeeding. Can. J. Public Health 75: 439-444, 1984.

GRIGSBY-HARRISON, G., BRANSON, R.S., VAUCHER, Y.E. Association of maternal smoking with body composition of the newborn. Am. J. Clin. Nutr. 38: 757-762, 1983.

HALLY, M.R., BOND, J., CRAWLEY, J., GREGSON, B., PHILIPS, P., RUSSELL, I. Factors influencing the feeding of first-born infants. Acta. Paediatr. Scand. 73: 33-39, 1984.

HAMILL, P.V.V., DRIZD, T.A., HOHNSON, V.L., REED, R.B., ROCHE, A.F., MOORE, W.M. Physical growth: National Center for Health Statistics percentiles. Am. J. Clin. Nutr. 32: 607-629, 1979.

HYTTEN, F., CHAMBERLAIN, G. In: <u>Clinical Physiology in Obstetrics</u>. Oxford: Blackwell Scientific Publications, 1980. pp. 193-233.

HYTTEN, F.E., LEITCH, I. Dietary requirements and dietary intakes during pregnancy. In: <u>The Physiology of Human Pregnancy</u>. Oxford: Blackwell Scientific Publishing Co., 1971. pp. 409-439.

MANNING-DALTON, C., ALLEN, L.H. The effects of lactation on energy and protein consumption, postpartum weight change and body composition of well nourished North American women. Nutr. Res. 3: 293-308, 1983.

:NALLY. E., HENDRICKS, S., HOROWITZ, I. A look at breast-feeding trends in Canada (1963-1982). Cdn. J. Public Health 76: 101-107, 1985.

METROPOLITAN LIFE FOUNDATION. Statistical Bulletin Vol. 64 (1): 2-9, 1983.

MYRES. A.W. A retrospective look at infant feeding practices in Canada: 1965-1978. J. Can. Diet. Assoc. 40 (3): 200-211, 1979.

NAISMITH, D.J., RITCHIE, C.D. The effect of breast-feeding and artificial feeding on body-weights, skinfold measurements and food intakes of forty-two primiparous women. Proc. Nutr. Soc. 34: 116A-117A, 1975.

PAO, E.M., HIMES, J.M., ROCHE, A.F. Milk intakes and feeding patterns of breast-fed infants. J. Am. Diet. Assoc. 77: 540-545, 1980.

PICONE, T.A., ALLEN, L.H., OLSEN, P.N., FERRIS, M.E. Pregnancy outcome in North American women. II. Effects of diet, cigarette smoking, stress, and weight gain on placentas, and on neonatal physical and behavioral characteristics. Am. J. Clin. Nutr. 36: 1214-1224, 1982a.

PICONE, T.A., ALLEN, L.H., SCHRAMM, M.M., OLSEN, P.N. Pregnancy ourcome in North American women. II. Effects of diet, cigarette smoking, stress, and weight gain on placentas, and on neonatal physical and behavioral characteristics. Am. J. Clin. Nutr. 36: 1214-1224, 1982b.

PIRIE, P., JACOBS, D., JEFFERY, R., HANNAN, P. Distortion in self-reported height and weight data. J. Am. Diet. Assoc. 78 (6): 601-606, 1981.

PRENTICE, A. The influence of maternal parity on breast-milk composition. In: Composition and Physiological Properties of Human Milk. Edited by J. Schaub. Elsevier Science Publishers B.V. (Biomedical Division), 1985. pp. 309-319.

QUANDT, S.A. Changes in maternal postpartum adiposity and infant feeding patterns. Amer. J. Phys. Anthropol. 60: 455-461, 1983.

ROSSO, P. A new chart to monitor weight gain during pregnancy. Am. J. Clin. Nutr. 41: 644-652, 1985.

ROWLAND, M.G.M. The "why" and "when" of introducing food to infants: growth in young breast-fed infants and some nutritional implications. Am. J. Clin. Nutr. 41: 459-463, 1985.

SARETT, H.P., BAIN, K.R., O'LEARY, J.C. Decisions on breast-feeding or formula feeding and trends in infant-feeding practices. Am. J. Dis. Child. 137: 719-725, 1983.

SCHELL, L.M., HODGES, D.C. Variation in size at birth and cigarette smoking during pregnancy. Am. J. Phys. Anthropol. 68 (4): 549-554, 1985.

SHIONO, P.H., KLEBANOFF, M.A., GRAUBARD, B.I., BERENDES, H.W., RHOADS, G.G. Birth weight among women of different thmic groups. J. Amer. Med. Assoc. 255 (1): 48-52, 1986a.

SPADY, D.W., ATRENS, M.A., SZYMANSKI, W.A. Effects of mother's smoking on their infants' body composition as determined by total body potassium. Ped. Res. 20 (8): 716-719, 1986.

STUNKARD, A.J., ALBAUM, J.M. The accuracy of self-reported weights. Am. J. Clin. Nutr. 34: 1593-1599, 1981.

WALKER, D.A., ABERNATHY, T.J., MALOFF, B.M.K., LOHNES, A.E. Infant feeding practices in Calgary during 1984. J. Can. Diet. Assoc. 48 (2): 108-112, 1987.

YEUNG, D.L., LEUNG, M., HALL, J., MEDINA, D. Longitudinal survey of infant nutrition. J. Can. Diet. Assoc. 40 (4): 288-295, 1979.

YEUNG, D.L., PENNELL, M.D., LEUNG, M., HALL, J. Breastfeeding: Prevalence and influencing factors. Can. J. Public Health 72: 323-330, 1981a.

YEUNG, D.L., PENNELL, M.D., LEUNG, M., HALL, J. Infant feeding practices. Nutr. Rep. Int. 23 (2): 249-260, 1981b.

ZIEGLER, E.E., O'DONNEL, A.S., NELSON, S.E., FOMON, S.J. Body composition of the reference fetus. Growth 40: 329-341, 1976.

F. CONCLUSIONS AND GENERAL DISCUSSION

In the present study, infant birth weight was positively correlated with maternal pregravid weight (r=0.28), length of gestation up to 40 weeks (r=0.27), pregnancy weight gain (r=0.24) and maternal age (r=0.10). Birth weight was negatively related with maternal cigarette smoking and gestational age greater than 40 weeks. Average weight at birth was 3.4 kg (7.4 lb) for male infants and 3.3 kg (7.2 lb) for female infants, weights which were slightly higher than mean infant birth weights established by the National Center for Health Statistics. Six low-birth-weight infants, weighing 2500 grams or less at birth, were included in the study. Breast-fed male infants were larger than formula-fed infants at birth, but rate of growth during the first four months of life was similar for males and for females within the two groups with the exception of male formula-fed infants, who grew more rapidly in length and head circumference than the breast-fed males.

In general, male infants grew more rapidly than female infants, and the rate of growth during the first two months of life far exceeded the rate of growth during the two to four month period. Solids were fed to breast-fed babies at 3.6 months and to formula-fed males and females at 3.2 and 3.0 months, respectively. Feeding solids did not apparently interfere with lactation or early infant growth.

Mothers in the breast-feeding and formula-feeding groups were similar in height, weight and pregnancy weight gain but breast-feeding mothers were significantly older and formula-feeding mothers were more commonly smokers. Women who smoked gained slightly more weight during pregnancy (NS). For the breast-feeding group, no effects of maternal postpartum weight changes on early infant growth were observed.

The results of this study indicate that maternal pregravid weight, length of gestation, pregnancy weight gain and maternal age are important determinants of infant size at birth. Growth of breast-fed infants during the first four months of life may be affected by maternal age, since a negative correlation between maternal age and infant weight gain was observed, but in this population, maternal postpartum weight gain, loss or maintenance were not correlated with infant growth during the first four months.

G. FUTURE STUDIES

Several areas of research merit further investigation. Previous studies indicated that infants born small for gestational age may (Rowland, 1985) or may not (Bhatia et al. 1983; Bhargava et al. 1985) exhibit catch-up growth during infancy and early childhood. In the present study, six full-term infants (slightly more than 2% of the sample) weighed 2500 grams or less at birth, resulting in their classification as low-birth-weight infants. Using Calgary Health Services' Infant Health Monitoring System and Child Health Records, low-birth-weight infants and babies born small for gestational age could be followed during the first six years of life or longer to assess growth in length (height) and weight to determine the presence or absence of catch-up growth. In addition, postnatal growth in these infants could be correlated with maternal weight gain during pregnancy and, using the same parameters, could be compared with average and large-sized babies and their mothers to test the assertion by Dimperio and Mahan (1985) that higher weight gain during pregnancy is associated with higher birth weights and improved postnatal growth.

A second area of interest pertains to lactational outcome in mothers who deliver by cesarean section. Although Kulski et al. (1981) reported that lactational outcome is similar following cesarean section or normal delivery, there is a paucity of information on this subject.

Thirdly, the observation from the present study that postpartum weight loss in smokers was reduced compared with non-smokers is of interest since this finding has not been reported elsewhere. Inclusion of larger numbers of smoking mothers and quantifying smoking would facilitate further evaluation of this trend.

Fourthly, maternal physical activity during pregnancy has been studied by several investigators, but there is more work to be done in this area. A study by Treadway and Lederman (1986) examined the effects of exercise on lactational performance in rats corresponding to milk yield, milk composition and early postnatal growth of offspring. Two human studies have recently been published, one by Langhoff-Roos et al. (1987) that evaluated effects of exercise on maternal lean body mass, pregnancy weight gain, maternal fat accretion and infant birth weight, and one by Wong and McKenzie (1987) that evaluated effects of aerobic fitness on maternal labor and delivery, infant birth weights and Apgar scores. Although these studies provide evidence for the beneficial effects of moderate exercise during pregnancy and during the early postpartum period, it would be advantagous to increase the number of subjects, vary the kind, intensity and duration of exercise, and evaluate effects of altitude combined with exercise on pregnancy and lactation outcomes.

Lastly, a comparison of self-reported and measured weights for the adult population in Calgary would be useful for verification of study results. Whereas Stunkard and Albaum (1981) and Pirie et al. (1981) reported relatively reliable correlations between self-reported and measured weights, variations in reliability are evident for different populations. Self-reported weights among Calgary residents may be more or less accurate than those reported elsewhere, but this can only be determined by a study of the population in question.

H. REFERENCES

BHATIA, B.D., BANERJEE, D., AGARWAL, D.K., AGARWAL, K.N. Exterogestate growth: relationship with maternal body size and dietary intakes. Indian J. Pediatr. 50: 241-246, 1983.

BHARGAVA, S.K., KUMARI, S., CHAUDHARY, P., BUTANI, R., SACHDEV, H.P.S. A longitudinal study of physical growth of small for date infants from birth to six years. Nutr. Res. 5: 707-713, 1985.

DIMPERIO, D.L., MAHAN, C.S. Influencing pregnancy outcome through nutrition and dietary changes. Md. Med. J. 34 (10): 997-1002, 1985.

KULSKI, J.K., SMITH, M., HARTMANN, P.E. Normal and caesarian section delivery and the initiation of lactation in women. Aust. J. Exp. Biol. Med. Sce. 59 (Pt. 4): 405-412, 1981.

LANGHOFF-ROOS, J., LINDMARK, G., KYLBERG, E., GEBRE-MEDHIN, M. Energy intake and physical activity during pregnancy in relation to maternal fat accretion and infant birthweight. Br. J. Obstet. Gyn. 94: 1178-1185, 1987.

PIRIE, P., JACOBS, D., JEFFERY, R., HANNAN, P. Distortion in self-reported height and weight data. J. Am. Diet. Assoc. 78 (6): 601-606, 1981.

ROWLAND, M.G.M. The "why" and "when" of introducing food to infants: growth in young breast-fed infants and some nutritional implications. Am. J. Clin. Nutr. 41: 459-463, 1985.

STUNKARD, A.J., ALBAUM, J.M. The accuracy of self-reported weights. Am. J. Clin. Nutr. 34: 1593-1599, 1981.

TREADWAY, J.L., LEDERMAN, S.A. The effects of exercise on milk yield, milk composition, and offspring growth in rats. Am. J. Clin. Nutr. 44: 481-488, 1986.

WONG, S.C., MCKENZIE, D.C. Cardiorespiratory fitness during pregnancy and its effect on outcome. Int. J. Sports Med. 8: 79-83, 1987.

I. APPENDICES

Alberta
SOCIAL SERVICES
AND COMMUNITY HEALTH
Division of Vital Statistics

PHYSICIAN'S NOTICE OF A LIVE BIRTH OR A STILLBIRTH

WEIGHING 500g OR MORE, OR GESTATION AGE OF 20 WEEKS OR MORE

PART I - TO BE COMPLETED WITHIN 24 HRS. OF BIRTH

NAME OF CHILD — SURNAME — FULL GIVEN NAMES (IF KNOWN) — HOUR — MTH BY NAME — DAY — YEAR

NAME OF FATHER — SURNAME — FULL GIVEN NAMES — AGE

NAME OF MOTHER — MAIDEN SURNAME — FULL GIVEN NAMES — AGE

PERMANENT ADDRESS OF MOTHER — HOUSE NO. STREET — NAME OF CITY OR MUNICIPALITY — POSTAL CODE — TELEPHONE NUMBER

PLACE OF BIRTH NAME OF INSTITUTION — LOCATION — LOCAL HEALTH AUTHORITY

COMPLETED WEEKS GESTATION — TOTAL PREGNANCIES (INCLUSIVE) — ☐ FEWER THAN FOUR PRENATAL VISITS TO PHYSICIAN AND/OR NO VISITS BEFORE 20 WEEKS — ONE PARENT FAMILY YES ☐ NO ☐

BIRTH WEIGHT ____ g — TOTAL LIVE BIRTHS (INCLUSIVE) — APGAR SCORE 1 MINUTE ☐☐ 5 MINUTES ☐☐ — ADOPTION YES ☐ NO ☐ UNDECIDED ☐

BORN ALIVE YES ☐ NO ☐ — SEX FEMALE ☐ MALE ☐ — VITAMIN K GIVEN YES ☐ NO ☐ — SINGLETON ☐ — RESUSCITATION

ONSET OF LABOUR SPONTANEOUS ☐ INDUCED ☐ — PROPHYLACTIC EYE DROPS GIVEN YES ☐ NO ☐ — TWIN ☐ 1ST ☐ 2ND ☐ — TRIP. ☐ 1ST ☐ 2ND ☐ 3RD ☐ — SIMPLE ☐ EXTENSIVE ☐

*DELIVERY

VERTEX - SPONTANEOUS ☐
- FORCEPS LOW/OUTLET ☐
MID ☐
DIFFICULT ☐

BREECH - SPONTANEOUS ☐
- ASSISTED ☐
EXTRACTED ☐
CAESAREAN SECTION ☐
REASON ____

APPARENT CONGENITAL ANOMALY YES ☐ NO ☐ DETAILS ____

SIGNIFICANT BIRTH INJURY YES ☐ NO ☐ DETAILS ____

*MATERNAL HEALTH CONCERNS (INCLUDE RUBELLA) — SPECIFY MEDICATION (PRENATAL AND POSTNATAL)

*ABNORMAL GENETIC HISTORY EITHER PARENT (INCLUDE CONGENITAL HEARING PROBLEMS)

PHYSICIAN'S NAME (PRINT) — ADDRESS — TELEPHONE NUMBER

SIGNED ____
PHYSICIAN'S SIGNATURE

PART II - TO BE COMPLETED BY NURSE AT TIME OF DISCHARGE OR 7 DAYS AFTER BIRTH (WHICHEVER IS EARLIER)

DATE OF ASSESSMENT ____
WEIGHT ____ g
CROWN TO HEEL LENGTH ____ cm
HEAD CIRCUMFERENCE ____ cm

	NORMAL	ABNORMAL
PHYSICAL EXAMINATION	☐	☐
MUSCLE TONE	☐	☐

DESCRIBE IF ABNORMAL ____

PKU SCREENING DONE ☐
VITAMIN K GIVEN IN NURSERY ☐
DRUGS GIVEN ____

NEONATAL CONDITIONS/CONCERNS

SEIZURES ☐ DETAILS ____
RESPIRATORY DIFFICULTIES ☐
BILIRUBIN > 342 u mol/L ☐
TREATED IN ICU ☐
OTHER CONCERNS ☐

FEEDING: BREAST ☐ FORMULA ☐

FOR ADOPTION ☐
FOR FOSTER CARE ☐
UNDECIDED ☐

DISCHARGED ☐☐ MTH DAY
DIED ☐☐ MTH DAY

FOLLOW-UP RECOMMENDATION ON MOTHER AND INFANT TO COMMUNITY HEALTH NURSE (C.H.N.)

FOLLOW UP IMMEDIATE ☐ *IF IMMEDIATE CALL C.H.N.
REGULAR ☐
CONCERNS ABOUT BONDING ☐
NEEDS SUPPORT ☐

COMMENTS ____

PLEASE PRINT — FAMILY PHYSICIAN NAME ADDRESS — PEDIATRICIAN NAME ADDRESS

SIGNED ____
REGISTERED NURSE NEWBORN NURSERY

* FOR FURTHER INFORMATION C.H.N. PLEASE CONTACT PHYSICIAN

DVS 3 REV(83/01)

COPY 3

NEWBORN CHART COPY

Calgary Health Services **CHILD HEALTH RECORD - B**

▶ Please Print With Black Ball Point Pen

Date of Birth Y M D	Birth Weight	Sex	Birth Order	Health Record Number

Child's Surname	First	Middle

Address	Postal Code	Clinic Number
1.	▶	▶
2.	▶	▶
3.	▶	▶

1 FEEDING

Check ✓ One	Birth to Discharge	to ... Weeks	to 2 mos.	4 to 6 mos.	to 6 mos.
Breast Only					
Breast With Supple...					
Formula					
Cow's Milk					

First Introduction of Cereal or Other Solid Foods. (Age to Last Full Month) ▷ Mos.

PRENATAL

Mother Attended Prenatal Classes (50% or More of Sessions)

☐ No ☐ Yes-Where ▷

Date of Discharge From Hospital of Mother Y M D	of Baby Y M D	Pre-Preg. Wt. kg	Mother's Ht. cm	Weight Gain During Pregnancy kg	Birth Control Was Taken Prior To This Conception ☐ No ☐ Yes	Interval From Last Pill To This Conception Mos.

3 IMMUNIZATION

Age (Last Complete Month)	DPT Y M D Init	Polio (Sabin) Y M D Init	DT Y M D Init	MMR Y M D Init	Td Y M D Init	Y M D Init	Y M D Init
mos.							
mos.							
mos.							
mos.							
mos.							
mos.							
mos.							
mos.							
mos.							

Initials confirm consent (the parent was provided with information, given time for discussion, and agreed to the administration of the immunization.)

4 CONGENITAL OR ACQUIRED DEFECTS

0-6 Months ☐ No Diagnosis	Corrected Y M D	6-18 Months ☐ No Diagnosis	Corrected Y M D
☐ Yes		☐ Yes	
☐ Suspected		☐ Suspected	

5 ILLNESS/INJURY

✓ ILLNESS requiring prescription and/or hospitalization.

✓ INJURY requiring hospitalization and/or 2 or more visits to a physician.

HOSPITALIZATION Write Number of Days to the Right of ✓.

Age	Resp.	G.I.	Skin	Other	Injury	Describe Illness or Injury
Discharge to 2 mos.						
2-4 mos.						
4-6 mos.						
6-9 mos.						
9-12 mos.						
12-18 mos.						
18-72 mos.						

6 DEVELOPMENT

Enter Code: P-Pass; O-Observation; R-Referral; Neg.(CHD); *Known Problem

Age (Last Complete Month)	Y	M	D	Wt.-Kg.	Ht.-Cm.	Head Circ. Cm.	Social	Fine Motor	Lang.	Gross Motor	Vision	Hearing	CHD
mos.													
mos.													
mos.													
mos.													
mos.													
mos.													
mos.													
mos.													

7 SCHOOL

Grade	Age	Y	M	D	Vision Without Glasses	Vision With Glasses	Audio

Congenital or Acquired Defects ☐ No ☐ Yes

Diagnosis

Chronic Medical Condition ☐ No ☐ Yes

Diagnosis

CLINIC REPORT

VITA

NAME: Doreen Audrey Walker

PLACE OF BIRTH: Saskatoon, Saskatchewan

YEAR OF BIRTH: 1953

POST-SECONDARY EDUCATION: B.S.H.Ec. 1975, R.D. 1976

HONOURS AND AWARDS: University of Alberta Bursary

RELATED WORK EXPERIENCE: Research project conducted for Calgary Health Services, 1985.

PUBLICATIONS: Walker DA, Abernathy TJ, Maloff BMK, and Lohnes AE. Infant feeding practices in Calgary during 1984. J Can Diet Assoc 1987;48(2):108-112.

Walker DA, Lee SJK, and McAllister RM. The effect of chronic beta-adrenergic blockade on training-induced changes in blood lipids in cardiac patients. [Abstract] Med Sci Sports Exer 1983;15(2):166.