CHANGES IN MATERNAL BODY COMPOSITION FROM MONTH ONE TO MONTH SIX POSTPARTUM IN 11 BREASTFEEDING, EXERCISING WOMEN

by

SHERRI KWASNICKI

B.H.K., The University of Windsor

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We accept this thesis as conforming to the required standard

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Department of **Human Kinetics**

The University of British Columbia
Vancouver, Canada

Date **Aug 13/97**
Abstract:

In vitro studies indicate that during lactation, lipolysis is significantly higher in the gluteo-femoral region compared to other periods in a woman's life. Additionally, there is a marked decrease in LPL activity in the femoral region during lactation (Rebuffe-Scrive, 1985). This suggests that fat is mobilized preferentially from the femoral region to be utilized for the production of milk. Animal studies clearly indicate that maternal fat, particularly gluteo-femoral fat, is utilized for the production of milk (Steingrimsdottir, 1980; Bergmann, 1994; Roberts, 1984). However, human studies present varying results (Quandt, 1983; Kramer, 1993; Dewey, 1993; Manning-Dalton, 1983; Naismith, 1973; Brewer, 1989). There is enough evidence, however, to suggest that there is a relationship between lactation and the reduction of gluteo-femoral fat.

It is well-documented that exercise aids in the reduction of body fat and therefore, it is hypothesized that exercise during the lactating, postpartum period will have the effect of mobilizing fat, especially gluteo-femoral fat, more readily than during any other period in a woman’s life and return a woman to her pre-pregnancy figure more quickly. The compounded effect of exercise and breastfeeding on improving maternal body composition may encourage more women to participate in both of these healthy activities, thus improving her and her infant’s health.

It was the purpose of this study to examine maternal body composition changes in 11 breastfeeding, exercising women from month one to month six.
postpartum. It was hypothesized that the breastfeeding, exercising women would experience a larger reduction in gluteo-femoral fat compared to abdominal fat and that they would return to their pre-pregnancy weight by six months postpartum.

Body weight, girth, skinfold, DXA measurements (BMC, BMD, Total body fat, body fat %, LTM, regional fat distribution), caloric intake, infant feeding patterns, infant size measurements, and estimated VO2max were studied in 11 breastfeeding exercising women from month one to month six postpartum. Significant differences were found in body weight, girths, skinfolds, DXA BMC, DXA BMD, DXA body fat %, DXA total body fat and VO2max in the subjects from month one to month six postpartum. The skinfold, girth and DXA regional fat distribution measurements do not suggest a regionalized, specialized functioning of body fat for the purpose of milk production and instead, the results suggest a more generalized, proportional loss of body fat from the abdominals, legs and trunk. The subjects did not return to their pre-pregnancy weights by 6 month postpartum as expected. From the present study, we cannot conclude that breastfeeding, exercising women lose fat or weight any more quickly than breastfeeding, non-exercising or formula feeding, non-exercising subjects. Instead, a multifactorial theory to weight and fat control during the postpartum period is suggested. This study is significant because it suggests that women can exercise and breastfeed thus improving their MVO2, their subsequent energy and stamina levels and their body composition without any detrimental effects to their infant and maternal milk production. This study also presents a very comprehensive analysis of body composition in this particular subject group including an examination of DXA values.
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DEFINITION OF TERMS

**Esterification:**
Fatty acid biosynthesis. Process of uptaking fatty acids into adipose tissue.

**Hormone-Sensitive Lipase**
Controls the release and efflux of fatty acids from adipose tissue (lipolysis).

**Lipoprotein Lipase**
Rate limiting enzyme. Controls uptake of triglyceride into adipose tissue (lipogenesis). It hydrolyzes triacylglycerol transported in very low density lipoproteins and chylomicrons, thereby making their triacylglycerol fatty acids available for uptake in various tissues, including adipose tissue.

**Multiparous**
Having given birth to more than one child

**Parturition**
Birth of infant

**Primiparous**
Having given birth to one child
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Last, but not least, I wish to express my appreciation to all participants of this study for their interest, enthusiasm and cooperation.
DEDICATION

This work is dedicated to Jim for his love, patience and understanding.

The difference between a successful person and others is not a lack of strength. Not a lack of knowledge. But rather in a lack of will.

Unknown
CHAPTER 1: INTRODUCTION

Breastfeeding, Overfatness, Adipose Tissue Distribution and Associated Health Risks

Health Implications of Breastfeeding

Growth throughout infancy is a complex process affected directly or indirectly by numerous interrelated factors. The prevailing factors include diet, the nutritional status and health of the mother and the occurrence of infection. In addition, social factors, economic status, cultural practices and biological factors may also play a significant role in growth.

The current trend in adult health care focuses on a preventative approach to health. Nutrition, exercise and stress control are emphasized. Far too little attention, however, has been directed towards a preventative approach to health care in infancy. Infancy is a stage of life in which rapid brain growth and dramatic physical development occurs. The immediate post-natal period is the time when nutrient requirements are most needed for cell division, cell enlargement and maturation of tissues and organs of full term, and in particular, of low birth weight infants (Kovar, 1984). The most effective form of infant feeding will, therefore, affect the development of the infant and provide him/her with the tools necessary to reach genetic potential. Lifelong health patterns are becoming established. Infancy
is a logical time to initiate preventative health care. The question arises as to whether breastfeeding is a method of preventative health intervention.

Studies have found that regardless of socioeconomic status, environmental factors or biological factors, breastfeeding appears to be more beneficial to the health of the child than formula feeding. Evidence suggests that breastfeeding protects against gastrointestinal disorders, respiratory illness, otitis media and promotes growth and psychological development in infants (Hanock et al, 1986; Kovar et al, 1984; Miller et al, 1984; Seward et al, 1984; Westover et al, 1989).

Several authors have calculated the age when breastfeeding alone becomes inadequate to meet the theoretical requirements of the infant with normal birth weight. Seward et al (1984) examined the research available regarding the recommended time period for exclusive breastfeeding and the results indicate that breastfeeding alone will be adequate until about the six month postpartum period, after which, alternate foods will need to be introduced.

Many organizations have taken an aggressive approach to the promotion of exclusive breastfeeding. Many are relying upon physicians and nurses to communicate accurate information and provide practical guidelines to patients regarding breastfeeding. These organizations tend to promote breastfeeding based on the health implications for the infant. Breast milk has been recognized for many years as the best food for infants under 6 months of age. However, if maternal
benefits could also be discovered, this would allow for more leverage in their struggle to promote the practice of breastfeeding.

**Health Implications of Overfatness**

Overfatness is associated with health complications, and this association has been reported in both longitudinal and cross-sectional studies. Large population studies (Build Study, 1979; Lew, 1979) have demonstrated consistent results which have been confirmed by numerous smaller studies. Bray et al (1989) discovered that long term obesity can have profound physiological effects showing that a high BMI score increases the likelihood of developing cardiovascular diseases, diabetes mellitus, gall bladder disease and some cancers. The psychological effects of obesity can also be devastating.

**The Effects of Exercise on Obesity**

The U.S. Surgeon General’s Report on Physical Activity and Health released in 1996 concluded that physical activity is important for weight control. The report states that by using energy and maintaining muscle mass, physical activity is a useful and effective adjunct to dietary management for avoiding weight gain or losing weight. The report cites a number of comprehensive review articles and meta-analyses that have examined the impact of exercise training on body weight and obesity. These reviews conclude that 1) physical activity generally affects body composition and weight favorably by promoting fat loss while preserving or
increasing lean mass 2) the rate of weight loss is positively related, in a dose-
response manner, to the frequency and duration of the physical activity session, as
well as to the duration (e.g. months, years) of the physical activity program; and 3) although the rate of weight loss resulting from increased physical activity without caloric restriction is relatively slow, the combination of increased physical activity and dieting appears to be more effective for long-term weight regulation than is dieting alone. This conclusive evidence has prompted many national organizations to aggressively promote exercise as a means of weight or fat control.

It is hypothesized that if exercise can be proven to return a mother more quickly to her pre-pregnancy figure, she may be more likely to initiate an exercise program. This may cause women to realize the benefits of exercise, experience results and begin to enjoy physical activity. Consistent exercise during the postpartum period may develop into a lifelong commitment to exercise. The Surgeon General’s Report also concluded that significant health benefits can be obtained by including a moderate amount of physical activity (e.g., 30 minutes of brisk walking or raking leaves, 15 minutes of running or 45 minutes of playing volleyball) on most, if not all, days of the week. The report found that physical activity reduces the risk of premature mortality in general, and of coronary heart disease, hypertension, colon cancer, and diabetes mellitus in particular. Physical activity also improves mental health and is important for the health of muscles,
bones and joints. Thus, by becoming involved in exercise during the postpartum period, a woman may be more likely to continue with her program and reap the many benefits of a more healthy lifestyle.

The Effects of Pregnancy and Breastfeeding on Obesity

Failure to lose the weight gained during pregnancy can lead to obesity (Tooke Crowell, 1995). Seventy percent of women are dissatisfied with their bodily appearance at 6 months postpartum. Twenty-five percent of these women claim a decrease in the frequency of intercourse because they felt unattractive due to weight gain. At one year postpartum, 39% of women were still dissatisfied with their appearance (Fischman, 1986).

One study found that pregnancy weight gain accounts for more than half the adult weight gains of overweight women who previously were of normal weight (Bradley, 1989). Women are often concerned about their body weight during and immediately after pregnancy (Hisner, 1986), in fact, Hisner found that 75% of women in their first few weeks postpartum were concerned with weight and 70% were concerned about their ability to return to their pre-pregnant figure. Greene (1988) found that women, who have an average amount of weight gain during pregnancy, will retain about 1 kg after the birth of each child. This amount is above the .45 kg per year normally gained with age. Studies (Greene, 1988) have
confirmed that women are heavier after pregnancy with at least one woman in ten retaining excessive weight (greater than 6.6kg).

Animal studies suggest that repeated pregnancies without lactation may dispose mothers to obesity (Jenn, 1988; as cited in Dewey et al, 1988). This suggests that lactation may be a method of preventing obesity.

**Adipose Tissue Distribution**

Bray et al (1988) reviewed studies examining regional fat distribution. The results indicate that abdominal or android fat predominance is a potent risk factor for cardiovascular disease, hypertension, stroke and diabetes. It has long been recognized that subcutaneous adipose tissue shows a characteristic regional distribution in men and women. Women have a predominance of fat in the gluteal and femoral regions while in men, the abdominal region has the largest adipose tissue thickness (Rebuffe-Scriva, 1985). Women have more fat and larger fat cells than men in the femoral region. One theory for this particular accumulation of adipose tissue in women could be that the femoral region subserves a specific function (Rebuffe-Scriva, 1985). This gender-specific fat deposition exposes the male population to a greater risk for developing cardio-vascular disease. It has been suggested that because abdominal fat has a more rapid turnover and is closer in proximity to the heart, that this places a large stress on the heart and can have a more damaging effect. However, this fact rarely comforts women. Instead, women,
based on the desire to achieve society's ideal body image, partake in many different methods of reducing lower body fat. Many use creams, pills, massage, exercise and dieting in an attempt to mobilize fat in this area. However, as many women will attest, lower body fat appears to prevail (Rebuffe-Scrive, 1985). Many women experience a reduction of fat in other areas but unfortunately, struggle with their attempt to reduce a more "stubborn" lower body fat.

This scenario experienced by women for ages, is documented and confirmed in the literature. Rebuffe-Scrive et al (1985) found that the Lipoprotein Lipase activity (LPL), the enzyme responsible for the uptake of triglycerides into adipose tissue, is higher in the femoral region compared to abdominal depots in non-pregnant women. This indicates that fatty acids are more readily taken up by the femoral tissue and stored as fat. However, the high level of LPL activity in the femoral region was enduring except during lactation, when a marked decrease in the LPL activity is seen in the femoral area. Rebuffe-Scrive also discovered that basal lipolysis was similar in femoral and abdominal depots in non-pregnant women except during lactation, when lipolysis increased and was significantly higher in the femoral region. Rebuffe-Scrive suggested that adipose tissue in different regions may have specialized functions.

Steingrimsdottir (1980) confirmed these results indicating that 20 days postpartum (post-pregnancy) in Osborne-Mendel rats, subscapular and abdominal
LPL activity was decreased in proportion to the size of the litter. Rats not allowed to lactate had LPL activity levels that were not significantly different than in non-pregnant controls. LPL activity in rats nursing four and eight pups was 36% and 2% of non-pregnant control values respectively. Scow et al (1977) found that non-suckling for forty-four hours decreased uptake of all lipids by mammary glands and increased uptake of triacylglycerol, fatty acids, and cholesterol by adipose tissue. Hamosh et al (1970), and McNamara et al (1986) confirmed these results.

Zammit et al (1985) proposed a multi-factor endocrine regulation of metabolism during lactation. The suggestion is that normal glucagon, high prolactin and low insulin levels associated with lactation affect rates of lipolysis and lipogenesis.

The literature indicates that during lactation, the enzymes responsible for storage of fat in femoral adipose tissue are less active and the enzymes responsible for the release of fat from femoral adipose tissue are more active. This would suggest a greater ability to mobilize fat from this region during lactation. This may offer women a very appealing opportunity to take advantage of this time-frame in attempts to alter her body composition.
Assessment of Adipose Tissue Distribution

The Waist to Hip ratio (WHR) is the most widely used method of indexing lower body fat compared to upper body fat distribution. The waist girth is measured and divided by the hip girth and a value greater than .8-.85 for women and .95-1.00 for men indicates health risks and demonstrates an android type physique (Krotkiewski et al, 1988). However, this measurement offers a crude assessment of regional fat distribution.

Several other indices have also been used. Most studies examining the area of lactation and its effects on body composition have utilized skinfold caliper readings (SF) and girth measurements to assess fat distribution.

Kramer et al (1993) designed two composite measurements for calculating lower body fat:

Lower body fat = hip girth + thigh girth + thigh SF

Lower body fat = hip girth

Kramer also designed a composite measurement for estimating upper body fat:

Upper body fat = triceps SF + biceps SF + subscapular SF + suprailiac SF

All of these composite measurements appear to provide more accurate information than just WHR but still are not ideal. Skinfold and girth measurements can only indicate regional body fatness and the fat that is measured is only subcutaneous. Other problems surface, for example, it is questionable whether the suprailiac
skinfold should represent upper body fat in Kramer's composite measurement. Many studies used triceps SF as an indicator of fatness (Quandt et al, 1983; Dewey et al, 1993). This is a poor choice for determining fatness during lactating as some studies have shown triceps SF increases during lactation indicating a possible redistribution of adipose fat (Dugdale et al, 1989; Brewer et al, 1989).

Manning-Dalton et al (1983) calculated composite measurements by categorizing fat distribution into distal and proximal depots:

\[
\text{Distal SF thickness} = \text{triceps SF} + \text{biceps SF} \\
\text{Proximal SF thickness} = \text{subscapular SF} + \text{costal SF} + \text{suprailiac SF} \\
\text{Distal circumference} = \text{mid-thigh girth} + \text{upper arm girth} \\
\text{Proximal circumference} = \text{buttocks girth} + \text{maximal thigh girth}
\]

Again, these measurements are crude and do not truly indicate localized fat deposition.

Defining fat distribution poses many methodological problems. As of yet, there is no non-intrusive method of accurately assessing regional fat distribution. The contradicting results, inherent in studies examining lactation and body fat distribution, stem from these methodological problems. Our study will attempt to more accurately assess lower body fat. Dual energy x-ray absorptiometry (DXA) will allow us, possibly, the most accurate method of determining regional fat deposition, although, it also presents its own problems with a reasonable short term precision of 1.3% for the lower limbs but 17.1% for the upper limbs (Drinkwater et
al, unpublished). Pritchard et al (1993) measured the ability of DXA to precisely measure regional fat distribution and found trunk fat% CV = 2.0%, lower limb fat% CV = 3.6%, head fat% CV = 1.1% and arm fat% CV = 3.4%. Snead (1993) found that DXA was able to identify 55% of the exogenous fat (lard positioned over the body in specified regions) as fat when it was in the trunk region compared with 96% when it was positioned over the legs. To the author’s knowledge, no study to date has used DXA to measure the changes in body composition in breastfeeding, exercising women.

Possible Mechanisms for Lactation and Maternal Fat Relationship

The Prolactin Relationship

Prolactin is the hormone responsible for inducing the production of milk during lactation. It also appears to be a primary factor promoting the mobilization of lower body fat. Zammit et al (1985) suggests that prolactin is responsible for decreased lipogenesis in adipose tissue and increased lipogenesis in mammary tissue. An increase in LPL activity in mammary glands and a concomitant suppression of LPL activity in adipose tissue has been induced in rats experimentally by variation in serum prolactin levels comparable to those caused by variable patterns of suckling (Zindr et al, 1974; as cited in Quandt et al, 1983). Frequent nursing results in high serum prolactin concentrations. Quandt et al (1983) found that decreasing fat area was associated with significantly shorter and more frequent
feeds. This suggests that the different fat change patterns result from differential activity of adipose tissue LPL, which is itself mediated by serum prolactin concentrations. Prolonging the time between nursing bouts results in low serum prolactin and reversion of LPL activity to non-lactating type patterns (Hamosh et al, 1970). In fact, Delvoye et al (cited in Quandt et al, 1983) found that, because of the short half-life of prolactin, a feeding frequency of more than six bouts per day is necessary to maintain elevated levels of the hormone.

Prolactin and caloric intake

In rats, prolactin has been shown to stimulate food intake (Roberts et al, 1984). Additionally, in most human studies, breastfeeding women consume an average of 500 kcal extra per day (Kramer et al, 1993; Manning-Dalton et al, 1983; Naismith et al, 1973; Brewer et al, 1989; Sadurskis et al, 1988; Thomson et al, 1970). Prolactin and breastfeeding obviously increase appetite levels. However, Steingrimsdottir (1980) indicates that prolactin-induced LPL activity shifts override even the obesity producing effects of a high calorie diet and that, even though the rats were consuming significantly more calories, they were still losing weight and fat.

Prolactin and activity level

Manning-Dalton et al (1983) found that their breastfeeding group exhibited low activity levels. Lovelady et al (1993) confirmed this finding, discovering that energy spent on physical activity during lactation was lower compared to formula -
feeding. Guillermo-Tuazon et al (1992) found that physical activity increased significantly from 6 weeks to 30 weeks in lactating subjects and thus, hypothesized that, as the prolactin levels decrease through the postpartum period, their activity levels were increased. These results suggest that perhaps prolactin also suppresses the urge to be active and that, as prolactin levels drop through late lactation, this suppression is reduced and the mother's desire to be active returns.

Sadurskis et al (1988) suggests that higher stress is required during lactation to mobilize the fat stores (i.e. shortage of food, heavy physical exercise). This suggests that perhaps a vigorous exercise program is required in order to display the lipolytic effects of lactation and a significant loss of fat.

Prolactin time-frame

Prolactin levels are highest during initial lactation (Kramer et al, 1993). This would indicate that the increase in adipose lipolysis would be most significant early postpartum. Results from Kramer's study (1993) support this hypothesis. However, other studies have shown results not to be significant until the 3-6 month period (Dewey et al, 1993; Manning-Dalton et al, 1983; Brewer et al, 1989; Sadurskis et al, 1988). The prolactin response to feeding declines as the period of lactation increases. This indicates that the lipolytic effect in adipose tissue will be decreased. However, the decreased prolactin response will also act to suppress appetite therefore, decreasing caloric intake. This would perhaps override the fact
that fat is not as easily mobilized and would then support the research that has found no significant results until the 3-6 month period. It may suggest that in early lactation, when prolactin concentrations are highest, the energetic demands of lactation would be offset by increased energy intake. Later in lactation, when prolactin concentrations drop, despite stable levels of milk production, one might expect an accelerated rate of weight or fat loss.

Prolactin and Parity Status

Harrison et al (1975) found significant declines in SF thickness with parity status. Brewer et al (1989) found primiparous women lost more weight and fat than multiparous women. The exact relationship between parity status and weight/fat loss is unknown. Perhaps prolactin levels and the associated lipolytic effect are affected by parity status.

Prolactin and Individual Variability

Individual prolactin levels may differ substantially and this could account for the large variability in subject results in this area.
SUMMARY AND CONCLUSION

Breastfeeding appears to be more beneficial to the health of the infant than formula feeding. Many organizations are taking an aggressive approach to the promotion of exclusive breastfeeding. These organizations tend to encourage women to breastfeed based on the beneficial effects on the child. However, if maternal benefits were discovered, these organizations could use this information to encourage women to breastfeed.

It has been shown that the failure to lose the weight gained during pregnancy can lead to obesity and, in fact, one study found that pregnancy weight gain accounts for more than half the adult weight gains of overweight women previously of normal weight (Bradley, 1989). Animal studies have also suggested that repeated pregnancies without lactation may dispose mothers to obesity (Jenn, 1988; as cited in Dewey et al, 1988). It is well known that exercise helps to reduce body weight and fat and therefore, a program consisting of breastfeeding and exercise will benefit both the mother and the infant.

During lactation, lipolysis is significantly higher in the femoral region compared to other stages in a woman's life. Additionally, there is a marked decrease in LPL activity in the femoral region during lactation. This suggests that fat is mobilized from the femoral region to be utilized for the production of milk.
Animal studies clearly indicate that maternal fat, particularly lower body fat, is utilized for the production of milk. However, it is difficult to generalize these results to humans because fat distribution patterns are so different. Human studies present varying results. This may be due to differing methodological approaches. There is enough evidence, however, to suggest that there is a definite relationship between lactation and the reduction of lower body fat.

The relationship between lactation and the reduction of body fat should be compounded once exercise is introduced, such that, women should experience a greater reduction in body fat, particularly lower body fat, with breastfeeding and exercise compared to no exercise intervention.

By controlling confounding variables and designing an appropriate indicator of lower body fat, the relationship between exercise, breastfeeding and maternal body composition should be more pronounced. As a result, nurses and physicians will be able to encourage women to both breastfeed and exercise in order to return to their pre-pregnancy figure more quickly. As a result, both the mother and the infant will benefit from these healthy activities.

**STATEMENT OF PROBLEM**

1. The primary purpose of this study was to examine the body composition changes over time in 11 breastfeeding/exercising women
STUDY PARAMETERS

The study group was composed of 14 subjects with 3 drop-outs for a total of 11 subjects. All subjects were non-adolescent, without medical or obstetrical complications, almost exclusively breastfeeding, less than one month PP, not presently taking medication, non-smokers and had experienced a pregnancy weight gain between 25-50 pounds. All subjects were from an middle-upper income neighbourhood from the Greater Vancouver area.

Breastfeeding is defined as subjects who exclusively breastfed for at least 4 months. Exclusive breastfeeding is defined as mothers feeding their infants only breast-milk, however, almost exclusive breastfeeding was accepted which allows vitamins, minerals, water or juice. Exercise is defined as subjects who participated in organized, consistent physical activity 4x/wk. The program consisted of 40 minutes of cardiovascular exercise involving walking, biking, running, fitness classes or stairmaster.

Maternal body weight, DXA total body fat and fat %, DXA regional fat distribution, DXA Bone mineral content (BMC), DXA Bone mineral density (BMD), DXA Lean tissue mass (LTM), Estimated Maximum Volume of Oxygen (VO₂max) and infant size measurements were taken at month one and month six postpartum. Caloric intake, physical activity and infant feeding patterns were also monitored.
HYPOTHESES

1. Breastfeeding, exercising women will have greater reductions of gluteo-femoral fat compared to abdominal fat

2. Breastfeeding, exercising women will reduce their body weight and body fat to pre-pregnancy levels

3. Breastfeeding, exercising women will increase their VO$_2$max

4. Breastfeeding, exercising women will experience a reduction in BMC and BMD
CHAPTER 2: REVIEW OF LITERATURE

This chapter is organized into four sections, each dealing with related areas which are fundamental to the stated problem. Related literature is reviewed, examined and utilized to support the indicated hypotheses. Section 1 examines the changes that a woman experiences in body composition throughout pregnancy. It appears that women may store a certain amount of fat throughout pregnancy as an energy depot for the production of milk during lactation. If lactation does not occur, it appears that this fat will be much more difficult to mobilize.

Section 2 examines the literature related to the effects of lactation on cellular metabolism. The research demonstrates that lactation induces a lipolytic response and suppresses lipogenic activity in the adipose tissue, especially the gluteal-femoral region.

Section 3 examines the changes that occur in maternal composition throughout lactation. This section is divided into two areas: animal studies and human studies. The animal research indicates that there is a clear relationship between lactation and the reduction of fat, particularly lower body fat. However, human research contains conflicting evidence.

Section 4 examines the relationship between lactation and exercise. Most of the research performed in this area has been on the effects of exercise on milk production.
production and composition. However, the research does indicate that exercise may compound the relationship between lactation and the reduction of maternal fat.

The intentions of this review are: (a) to illustrate that cellular metabolism during lactation promotes the mobilization of maternal fat (b) to illustrate that lactation reduces maternal fat, particularly lower body fat and (c) to illustrate that exercise combined with lactation will further enhance the mobilization of maternal fat.
Section 1: Composition Changes During Pregnancy

Body weight is increased during pregnancy. Pipe et al (1979) found a mean weight increase of 10.4 +/- 0.53 kg during pregnancy. Van Raaij et al (1989) confirmed this value finding an average weight increase of 11.8 +/- 3.7 kg during pregnancy. This weight is obviously comprised partly of the weight of the fetus and placenta. However, the weight of the fetus and placenta does not account for the total weight gain. Rather, Pipe et al (1979) found total body water to be increased by 7.2 +/- 0.48 kg during pregnancy. Pipe also discovered that total body water at 6-15 weeks postpartum was similar to those at the first measurement in early pregnancy. Furthermore, Butte et al (1984) found that approximately 2 kg of water is lost in the puerperium. This would suggest that, in order to control for water loss in the early postpartum period, body composition measurements should not be taken until approximately 1 month postpartum.

During pregnancy, both in women and in animals, there is an increase in the weight of fat and lean tissues of the mother, quite apart from the products of conception, the uterus and related structures. The accepted explanation for this is that the mother is storing energy to support the energy demands of lactation. Van Raaij et al (1989) discovered that the gain in maternal fat stores over pregnancy was equivalent to 2.0 +/- 2.6 kg. Furthermore, fat deposition is enhanced, especially in the lower body during pregnancy. It has been suggested that the fat gain of
pregnancy serves the primary purpose of providing energy for milk production. It is possible that this fat can be mobilized more easily during lactation and therefore, allows a woman to achieve her pre-pregnancy figure more quickly. Dugdale et al (1989) suggests that the high levels of estrogens during pregnancy promote the gynoid distribution of fat, which is predominantly peripheral and that this tendency continues for several months. It has been suggested that, during lactation, the fat in these areas is mobilized which would account for some studies displaying a redistribution of fat during lactation and a short term increase of subcutaneous fat in the upper limbs while the total body mass and fat mass were decreased (Brewer et al, 1989, Quandt et al, 1983)

**Section 2: Cellular Metabolism During Lactation**

Table 2-1, constructed from the data obtained by Rebuffe-Scrive (1985), demonstrates the differences in lipolysis and lipogenesis at different stages in a woman's life. Notice that during lactation the LPL activity in the gluteo-femoral area is decreased substantially, therefore, indicating a decreased ability to uptake and store fat in the adipose tissue in this region. Also notice that the lipolytic enzyme activity in the gluteo-femoral region is increased substantially, therefore, indicating an increased ability to release fat from this region. This data suggests that during lactation women will be more able to mobilize fat from their lower body and therefore change their body composition more easily.
Table 2-1 supports the hypothesis that female adipose tissue distribution might be caused by regionally specific purposes of energy depots. McNamara et al (1986), supported this theory, suggesting that adipose tissue in Holstein Heifers adapts prepartum for increased release of energy, meets peak lactational demand by ceasing synthesis and increasing lipolysis and recovers synthesis dramatically to replenish body energy stores while also maintaining levels of lipolysis in support of lactation.

Table 2-1: Regional Characteristics of adipocytes during pre-menopause, pregnancy, lactation and post-menopause

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<tr>
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<th>Pre-menopause</th>
<th>Pregnant</th>
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<td>Abdominal</td>
<td>moderate</td>
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<td>Abdominal</td>
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<td>Gluteo-femoral</td>
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Lipolytic Activity

Rebuffe-Scrive (1985) studied healthy women during menstruation, pregnancy and lactation. Basal lipolysis was similar in abdominal and gluteo-femoral regions in non-pregnant women. However, during lactation, lipolysis was significantly higher in the femoral region. The lipolytic effect of noradrenaline was significantly less in the femoral region in the non-pregnant women and during early pregnancy. However, the lipolytic response was the same in both regions in
lactating women. Additionally, Scow et al (1977) found 60% of triacylglycerol oleic acid, 13% of cholesterol, and 8% of phosphatidylcholine in chylomicrons were taken up within 11 minutes of lactation by mammary gland, whereas, negligible amounts were taken up by adipose tissue. It was also discovered that non-suckling for 44 hours decreased, markedly, uptake of all lipids by mammary gland and retarded clearance of chylomicrons from blood, while it significantly increased uptake of triacylglycerol fatty acids and cholesterol by adipose tissue. Zammit et al (1985) suggests that high prolactin concentrations associated with lactation are responsible for the increase in lipolysis in adipose tissue.

**LPL Activity**

Rebuffe-Scrive et al (1985) found that LPL activity was higher in the femoral than in the abdominal region except during lactation when a marked decrease in the LPL activity was seen in the femoral region. The LPL activity remained unchanged in the abdominal region in all patient groups.

Steingrimsdottir et al (1988) found in Osbornel-Mendel rats that twenty days postpartum, LPL activity was decreased in proportion to the size of the litter. Rats not allowed to lactate had LPL activity levels that were not different from non-pregnant controls. LPL activity levels in rats nursing 4 pups and 8 pups was reduced to 36% and 2% respectively of control values. Mammary LPL activity was increased more than 10 fold in fats nursing 4 or 8 pups.
Scow et al (1977) and Hamosh et al (1970) found that non-suckling decreased LPL activity in mammary glands while it increased activity in adipose tissue.

These results suggest that reciprocal changes in LPL activity in mammary gland and adipose tissue, as occur during lactation, result in diversion of chylomicron lipids from one tissue to the other. In other words, fat is mobilized from the gluteo-femoral region and transported to the mammary gland for the production of milk. Table 2-2 summarizes the research findings in this area.
Table 2-2: Lipolysis and lipogenesis changes as a result of breastfeeding

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<tr>
<th>STUDY</th>
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<th>FINDINGS</th>
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<td>Rebuffe-Screve</td>
<td>Healthy women studied during menstruation,</td>
<td>Adipose tissue lipolysis and LPL activity</td>
<td>Basal lipolysis was similar in both regions in non-pregnant women.</td>
<td>The control group was significantly older than the other groups. Changes were only analyzed for one month postpartum. Activity levels and caloric intake were not assessed.</td>
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<td>(1985)</td>
<td>pregnancy and lactation</td>
<td>were studied in biopsies from the femoral</td>
<td>During lactation, lipolysis was significantly higher in the femoral</td>
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<td>and abdominal depots.</td>
<td>region. The lipolytic effect of noradrenaline was significantly less</td>
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<td>decrease in the LPL activity was seen in the femoral region. The LPL</td>
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<td>activity remained unchanged in the abdominal region in all patient</td>
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<td>groups. This suggests that adipose tissue in different regions may have</td>
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<td>Steingrimsdottir et</td>
<td>Non-pregnant, pregnant, and postpartum 12</td>
<td>Adipose tissue fat cell size and LPL activity</td>
<td>Twenty days PP, both retroperitoneal fat cell size and LPL activity</td>
<td>Generalizability of results to humans.</td>
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<td>al (1980)</td>
<td>week old Osborne-Mendel rats</td>
<td>were decreased in proportion to the size of</td>
<td>were decreased in proportion to the size of the litter. Rats not allowed</td>
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<td>the litter. Rats fed either a standard</td>
<td>to lactate had fat cell sizes and LPL activity that were not significantly</td>
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<td>laboratory diet or a high-fat diet.</td>
<td>different than in non-pregnant controls. Fat cell size and LPL activity</td>
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<td>in rats nursing 4 pups were reduced to 77% and 36% of control,</td>
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<td>respectively. Those nursing 8 pups, demonstrated a further reduction of</td>
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<td>fat cell size to 38% and of LPL activity to 2% of non-pregnant control</td>
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<td>values. High-fat feeding and obesity did not prevent the fat loss and</td>
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<td>decreased LPL activity associated with lactation; fat cell size was</td>
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<td>decreased to 61% and LPL activity to 3% of control values. Values for</td>
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<td>the subcapsular depot followed essentially the same pattern as that</td>
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<td>observed for the retroperitoneal depot. Mammary LPL activity was</td>
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<td>increased more than 10-fold in rats nursing 4 or 8 pups.</td>
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<td>Lafontant et al</td>
<td>18 women, 8 men aged 37-79 years; 8 below</td>
<td>Fat cells from the thigh were taken from</td>
<td>Fat cells from the lateral part of the thigh exhibit resistance to</td>
<td>There may be differences between genders. Age may be a factor.</td>
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<td>(1979)</td>
<td>weight, 9 mildly obese, 7 normal.</td>
<td>patients undergoing hip prosthesis. A control</td>
<td>adrenaline. Found that alpha and beta receptor sites exist in the</td>
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<td>group underwent an abdominal biopsy.</td>
<td>membrane of human fat cells and the balance between the 2 receptor-</td>
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<td>site activities could be different depending on the anatomical</td>
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<td>localization of the fat deposits.</td>
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Increased lipogenesis  
Increased L.P. non-esterified F.A.  
Variable lipogenesis  

**ADIPOSE TISSUE**  
Decreased Lipogenesis  
Increased Lipolysis  
Decreased Anti-lipolysis  
Decreased L.P. non-esterified FA  

**LIVER**  
Normal lipogenesis  
Increased Glucose production  

**NORMALGLUCAGON**  

**HIGH PROLACTIN**  

**LOW INSULIN**  |  |  |  |  |
<p>| Kather et al  | 4 males, 2 females aged 20-40 years | Effect of adrenaline on adenylyl cyclase activity in membranes prepared from human abdominal and gluteal adipose tissue was examined. | Adenylyl cyclase from abdominal tissue responded with a significantly higher rate of cAMP formation than that from gluteal tissue from the same patients. Basal, fluoride and adrenaline stimulated adenylyl cyclase activities are lower in gluteal membranes than in abdominal preps. Effect of adrenaline on adenylyl cyclase activity in membranes prepared from human abdominal and gluteal adipose tissue was examined. Stimulation of lipolysis is mediated through activation of the membrane-bound adenylyl cyclase. Regional differences in the lipolytic response to hormones, thus, might be reflected in differences in the responsiveness of this key enzyme to adrenaline. | Small sample size. There may be differences between genders. |</p>
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<td>60% of triacylglycerol oleic acid, 13% of cholesterol, 8% of phosphatidylcholine in chylomicrons were taken up within 11 minutes by mammary gland whereas, negligible amounts by adipose tissue.</td>
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<td>McNamara et al (1986)</td>
<td>15 first lactation Holstein Heifers</td>
<td>Subcutaneous adipose tissue was biopsied at -1, -5, +.5, 1, 2, 6 months PP</td>
<td>From 1 to .5 months prepartum there was a 54% reduction in lipogenesis, 16% reduction in esterification, 54 and 77% increase in norepinephrine and epinephrine-stimulated FFA release, 28% increase in epinephrine-stimulated glycerol release. The immediate PP period (.5-1 month) showed a decrease in lipogenesis to 5% and esterification to 50% of -1 month rates. During this period, norepinephrine-stimulated FFA release increased 128% and norepinephrine and epinephrine stimulated glycerol release increased 30% and 87%. Basal glycerol release doubled during this period, while basal FFA release increased to near prepartum levels. Catecholamine-stimulated FFA and glycerol release decreased from the peak during mid-lactation, but remained elevated compared to prepartum levels. Adipose tissue adapts prepartum for increased release of energy, meets peak lactational demand by ceasing synthesis and increasing lipolysis and recovers synthesis dramatically to replenish body energy stores while also maintaining elevated levels of lipolysis in support of lactation.</td>
<td>Generalizability of results to humans.</td>
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<td>Hamosh et al (1970)</td>
<td>Adult female Sprague-Dawley rats</td>
<td>Effect of pregnancy and lactation on LPL activity in adipose and mammary tissues and on plasma TG concentrations were studied in the rat.</td>
<td>Plasma TG concentrations increased 3-fold between the 12th and 20th days of pregnancy, then decreased during the next 2 days. It increased at parturition, then fell sharply and remained low through lactation. LPL activity in pararnetral adipose tissue increased 3-fold between the 9th and 12th days of pregnancy and then decreased slightly during the next 7 days. It decreased on the 20th day, declined again at parturition and stayed low throughout lactation. LPL activity in the inguinal-abdominal mammary glands increased very slowly during the first 20 days of pregnancy. It then increased the next day and then decreased sharply at parturition, then increased after parturition sharply. LPL activity in mammary gland remained high as long as the mother suckled. Non-suckling for 9 hours decreased mammary gland LPL activity to near zero and increased plasma TG concentration. Non-suckling also increased LPL activity in adipose tissue. Plasma TG concentration was inversely related to the LPL activity in mammary tissue during the last 2 days of pregnancy and throughout lactation.</td>
<td>Generalizability of results to humans.</td>
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Section 3: Composition Changes during Lactation

a) Animal studies

Steingrimsdottir et al (1980) studied 12 week old Osborne-Mendel rats. At 20 days postpartum, retroperitoneal fat cell size was decreased in proportion to the size of the litter. Rats not allowed to lactate had fat cell sizes that were not significantly different from non-pregnant controls. Fat cells in rats nursing 4 and 8 pups was reduced to 77% and 38% of control values. Values for the subscapular depot followed essentially the same pattern. Bergmann et al (1994) confirmed these results finding that the lactating mouse had a significantly lower body fat content and smaller adipocyte diameter than the controls. Roberts et al (1984) found that at the same levels of dietary intake, lactating rats lost more weight and total body fat than did Virgin controls. These studies indicate that maternal fat is mobilized throughout lactation.

However, Roberts et al (1984) also discovered that lactating rats fed ad libitum expended 34.9% less energy on activity and maintenance than did control animals. It was also found that the dietary intake of the breastfeeding group fed ad libitum was slightly greater than the control group. This would indicate that the efficiency of energy use and appetite is increased substantially during lactation. However, Steingrimsdottir et al (1980) found that high fat feeding and obesity did not prevent
fat loss and decreased LPL activity associated with lactation. Fat cell size was
decreased to 61% and LPL activity to 3% of control values during high fat feeding
conditions.

Animal research demonstrates, conclusively, that lactation promotes the
reduction of maternal fat. Table 2-3 summarizes the research findings in this area.

Animal research allows for ultimate control of activity levels and dietary intake.
Additionally, the strains utilized as subjects tend to have very similar physiological
characteristics. This would control for differences in hormonal responses, physical
characteristics and basic anatomical differences. Animals also are not motivated by
emotions. Humans, however, are motivated to eat or be active based on extraneous
factors. Fat distribution is also very different in humans compared to animals. The
problem, therefore, arises as to whether the results found in animals, can be
generalized or reproduced in humans.
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<tr>
<td>Bergmann et al</td>
<td>72 female breeders of the inbred mouse strain HLG</td>
<td>Measured body fat, body water, fat-free dry weight, adipocyte diameter and organ weights of liver and heart.</td>
<td>The lactating mouse had a significantly lower body-fat content and smaller adipocyte diameters as well as a higher body-water content that the controls. Even 42 days after weaning, the breeding females did not reach the values of the control animals.</td>
<td>Generalizability of results to humans.</td>
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<td>(1994)</td>
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<tr>
<td>Steingrimsdottir et al</td>
<td>Non-pregnant, pregnant, and postpartum 12 week old Osborne-Mendel rats</td>
<td>Adipose tissue fat cell size and LPL activity determined in the retroperitoneal and subscapular depots. Rats fed either a standard laboratory diet or a high-fat diet.</td>
<td>Twenty days PP, both retroperitoneal fat cell size and LPL activity were decreased in proportion to the size of the litter. Rats not allowed to lactate had fat cell sizes and LPL activity that were not significantly different than in non-pregnant controls. Fat cell size and LPL activity in rats nursing 4 pups were reduced to 77% and 36% of control, respectively. Those nursing 8 pups, demonstrated a further reduction of fat cell size to 38% and of LPL activity to 2% of non-pregnant control values. High-fat feeding and obesity did not prevent the fat loss and decreased LPL activity associated with lactation; fat cell size was decreased to 61% and LPL activity to 3% of control values. Values for the subscapular depot followed essentially the same pattern as that observed for the retroperitoneal depot. Mammary LPL activity was increased more than 10-fold in rats nursing 4 or 8 pups.</td>
<td>Generalizability of results to humans.</td>
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<tr>
<td>(1980)</td>
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<tr>
<td>Roberts et al</td>
<td>Virgin and Lactating rats</td>
<td></td>
<td>Lactating rats fed ad libitum expended 34.9% less energy on activity and maintenance than did control animals. Indicates that the efficiency of energy use is increased substantially during lactation. Dietary intake of the BF group fed ad libitum was slightly greater than control group. Body weight and total body fat decreased by small amounts. At the same levels of dietary intake, lactating rats lost more weight and total body fat than did the virgin controls.</td>
<td>Generalizability of results to humans.</td>
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<tr>
<td>(1984)</td>
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b) **Human Studies**

i) **Positive relationship between lactation and maternal fat reduction:**

Many studies indicate a relationship between lactation and weight and fat loss, however, an exact pattern has yet to be determined.

Quandt et al (1983) discovered that subscapular skinfolds decreased significantly with breastfeeding but upper arm fat area increased. This indicates a redistribution of maternal fat. Quandt found that weight was decreased in all subjects but no control group was used so this is difficult to interpret.

Kramer et al (1993) discovered that exclusively or partially breastfed subjects had significantly larger reductions in hip circumference and were closer to their pre-pregnancy weight at one month postpartum. Kramer’s results suggest that greater weight losses occur during the period when prolactin concentrations are highest.

Dewey et al (1993) discovered weight loss from 1-12 months postpartum was significantly greater in breastfeeding subjects than formula feeding subjects, primarily due to differences between 3 and 6 months. In contrast to Kramer’s results, this suggests that as prolactin levels begin to drop, appetite may be suppressed and weight loss occurs. In both groups, there was an increase in triceps skinfolds during the first 4 months followed by a plateau. The breastfeeding subjects experienced a net loss in triceps skinfold thickness, whereas, formula
feeding mothers gained at this site. This evidence contradicts Quandt's findings of fat deposition. This contradiction may be a result of different methodological approaches.

Sadurskis et al (1988) found the average fat content was unchanged during the first 2 months of lactation and then a slight loss occurred during the following 4 months. These results support Dewey's findings of delayed fat loss during lactation. However, Sadurskis did not measure a control group, so again, the results are difficult to interpret.

Guillermo-Tauzon et al (1992) also found body weight and body fat to decrease, however, no control group was examined.

Butte et al (1984) indicated a loss of 5 kg at 4 months postpartum and body fat by 2%, however, no control group was used. Butte also noted that triceps and biceps skinfold did not change significantly but suprailiac, subscapular and sum of skinfolds decreased significantly. Butte et al (1985) later confirmed these results, but again, a control group was not measured.

ii) No relationship between lactation and maternal fat reduction:

Other studies demonstrate no relationship between breastfeeding and body composition. Manning-Dalton et al (1983) found that percent lactation accounted
for only 10% of the variance in maternal weight changes. Dugdale et al (1989) confirmed these findings, discovering that the changes in body weight and skinfold were not affected by the duration of lactation.

Naismith et al (1973) found that formula feeding resulted in a greater reduction in the suprailiac skinfold compared to breastfeeding.

Brewer et al (1989) discovered no significant differences in total weight loss between breastfeeding and formula feeding groups. It was also found that a significant fat loss during the first 3 months occurred only in formula feeding subjects. Breastfeeding and combined feeding subjects experienced a significant loss between 3 and 6 months. These results again suggest that weight loss is dependent upon the varying levels of prolactin concentrations that occur during the postpartum period. Brewer also discovered a significant decrease in suprailiac and subscapular skinfolds during 3-6 months in the breastfeeding group.

Atalah et al (1983) found both breastfeeding and non-breastfeeding groups exhibited non-significant, slight changes in weight and body composition. Madhavapeddi et al (1992) confirmed these results, finding mean body weights of mothers at the end of 6 months was similar to those observed in initial months of lactation. Only 1-2 kg of body weight was lost during 18 months breastfeeding.
However, this study used poverty-stricken subjects who may not have had much weight to lose.

Van Raaij et al (1989) found weight and fat mass unchanged between weeks 5-9 postpartum and results were similar for breastfeeding and non-breastfeeding subjects. However, 9 weeks may not be long enough to allow for noticeable differences to occur.

The documented results and patterns vary due to poor methodological approaches, lack of control groups, different assessment tools for determining regional deposition and lack of control for confounding variables. Additionally, because none of the studies have examined long term effects post-lactation, there is no direct information available on whether there is any recovery of energy reserves at the end of lactation. Table 2-4 summarizes the research in this area.
Table 2-4: Composition changes during lactation: human studies

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<tr>
<td>Harrison et al (1975)</td>
<td>No info. given</td>
<td>SF (triceps, calf, subscapular, supra-iliac)</td>
<td>Significant declines in SF with parity status. Significant decline in body weight (corrected for ht. variation) occurs with increase in lactation period; Change still detectable if use Ponderal index</td>
<td>The outline of subjects studied, methods of data collection, breast-feeding periods, length of study was VERY poor. No info. on energy intake or energy output. No control group.</td>
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<tr>
<td>Kramer et al (1993)</td>
<td>24 women grouped into exclusively BF, partially BF, FF exclusively.</td>
<td>Initial interview 2-3 days PP. Data on demographic variables, previous pregnancies, wt. History, pre-pregnancy wt., plans for feeding new child, how previous children had been fed. Data collected 1x/month for 6 months. Collected weight, height, SF (tricep, bicep, subscapular, supra-iliac, mid-thigh) girths (mid-arm, waist, hips, mid-thigh), dietary intake (3-24 hr dietary recalls), physical activity (LTPA). 7 day/24 hr grid record of infant feeding.</td>
<td>BF exclusively or partially BF had significantly larger reductions in hip circumference measurements and were less above their pre-pregnancy weights at one month PP. Mean daily energy intake in BF and CF groups was 462 kcal more per day. Physical activity did not vary significantly.</td>
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<td>Manning-Dalton et al</td>
<td>27 well-nourished BF women. Non-adolescent, primagravid, middle to upper SES, no medical complication</td>
<td>Interviews 2, 4, 8, 12 wks PP. Measurements were weight, SF (bicep, triceps, subscap, costal, supra-iliac, umbilical), girths (upper arm, max-thigh, mid-thigh, buttocks, umbilical). Dietary intake by 24 hr. recall method. Maternal activity scored on a 3 point scale. Percent lactation calculated. Percent ideal weight for height calculated.</td>
<td>Caloric intake of women in BF exclusive group and combined group was significantly different at the 3rd month, although the FF group ate consistently less. Maternal activity was low. The weight change of each individual between the 12th and 90th day was positively correlated with average caloric intake. Not statistically significant but people who BF the least, lost the most weight. Women with largest net weight gain in pregnancy lost the most weight. Notable changes in SF but none significant. Significant decreases in the proximal SF and proximal circumferences. Percent lactation accounted for only 10% of the variance in maternal weight change.</td>
<td>Activity levels may be inaccurate as study performed during cold winter months. No non-lactating control groups.</td>
</tr>
<tr>
<td>Naismith et al</td>
<td>22 BF exclusively for 3 months 20 Bottle feeding</td>
<td>Measurements were completed every 2 weeks for 12 weeks and then at 6 months. Weight, SF (biceps, triceps, subscapular, supra-iliac). Food intakes estimated from 3 day food recall.</td>
<td>Significant decrease in the supra-iliac SF with Bottle feeding losing more fat in this region. Caloric intake of BF mothers was substantially higher. 11 of 20 bottle feeding were dieting. Significant weight losses in both groups.</td>
<td>Study only 3 months. No information on activity levels. Did not control for dieting. Did not discuss differences between 2 groups.</td>
</tr>
<tr>
<td>Dugdale et al</td>
<td>151 Australian women some BF others weaned early.</td>
<td>Mothers were measured every month PP up to 12 months. Measured body weight and triceps SF.</td>
<td>There was a significant weight loss in the first few months but this leveled off by 7 months. The triceps SF increased significantly up to 5 months PP and then decreased steadily until it was below the 1 month PP value. Changes in body weight and SF were not affected by the duration of lactation, smoking or the educational achievement of the mothers, but were influenced by the initial BMI and the desire to lose weight.</td>
<td>Triceps SF not an appropriate indication of body fat. No indication of levels of Breastfeeding. No indication of activity levels. No indication of caloric intake.</td>
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<td>Adair et al</td>
<td>125 rural Taiwanese women were studied through 2 consecutive pregnancies and 225 studied throughout lactation</td>
<td>Weight, SF (triceps, subscapular), height measured 1x during first pregnancy and then at regular intervals during L1, P2 and L2</td>
<td>After an initial increase from birth to one month PP, mean weight and SF declined throughout lactation. Patterns of weight change during lactation period 1 and 2 are similar. Greater weight loss in L2. Max SF occurred between 1 and 3 months PP and slowly declined thereafter. Mothers who lost weight tended to be fatter at the beginning of lactation.</td>
<td>No control group. No information regarding activity or nutritional levels. No information regarding levels of lactation. Large variability occurred. No information regarding how long data collected during lactation period.</td>
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<td>(1983)</td>
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<td>Brewer et al</td>
<td>56 women recruited through mail and telephone before delivery with assistance from a local women’s hospital. Assigned to BF, FF, CF groups.</td>
<td>Mothers visited in hospital 1-2 days PP and at home 3 and 6 months PP. Obtained data on SES, educational background, previous pregnancies, planned method of infant feeding. Weight, SF (triceps, subscapular, supra-iliac), mid-arm muscle circumference. Infant feeding information collected from month questionnaires. 3 day maternal food records completed at 3 and 6 months. Activity levels assessed.</td>
<td>No significant difference in total weight loss between BF and FF groups. BF group experienced a significant weight loss from 3-6 months. A significant fat loss during first 3 months occurred only in FF. BF and CF experienced a significant loss between 3-6 months. Supra-iliac and subscap SF decreased over 6 months in all groups with the supra-iliac region reflecting a significant feeding method effect. A significant decrease in supra-iliac and subscap SF occurred between 3-6 months in BF. Increase in triceps SF at 3 months in BF. Lactating mothers consumed more calories. Greater weight losses observed in mothers with lower pre-pregnancy weight. Higher PP weight was associated with greater weight losses. Primiparous lost more weight during early PP months. Older multi-parous women lost more weight from 3-6 months.</td>
<td>A longer study would indicate enduring results.</td>
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<td>Sadurskis et</td>
<td>23 healthy BF Swedish women. BF</td>
<td>Measurements were taken before pregnancy, 5-10 days PP, 2 months PP and 6 months PP. Maternal body weight, total body water, total body potassium, RMR. Fat free weight was calculated. Food intake was measured 4 consecutive days. Physical activity was assessed with diary before pregnancy and 2 months PP. Breast milk output (weight of baby before and after feeding for 24 hrs) and milk energy output were also estimated.</td>
<td>Average fat content unchanged during first 2 months of lactation and then a slight loss occurred during the following 4 months. Energy intake increased during lactation. RMR increased slightly during lactation despite a decrease in fat-free body weight 2 and 6 months PP. Total body water dropped from 55% pre-pregnancy to 50% 2 months PP and 51% 6 months PP. Levels of activity did not change from pre-pregnancy levels.</td>
<td>No control group used. Use of total body fat based on total body potassium and total body water may be inappropriate.</td>
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<td>al (1988)</td>
<td>fully for 137 days +/- 52 days and partially for 82 +/- 46 days.</td>
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<td>Lovelady et</td>
<td>9 BF women</td>
<td>HR, dietary intake, milk energy output, total energy output calculated</td>
<td>Weight loss averaged 38 g/day or 1.14kg/month. Energy spent on physical activity during lactation lower than bottle-feeding.</td>
<td>No control group.</td>
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<td>al (1993)</td>
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<tr>
<td>van Raaij et</td>
<td>57 healthy pregnant women</td>
<td>Body weight, FM, BMR, SF (biceps, triceps, sub-scapular, supra-iliac, quad) and girths were measured longitudinally from early pregnancy until 2 months PP</td>
<td>Weight gain over pregnancy was 11.8 (3.7) kg. Gain in maternal fat stores over pregnancy was 2.0(2.6)kg. Five week PP, body weight and body fat mass were 2.7 (3.3) kg and 2.0 (2.6)kg above pre-pregnancy values. Weight and fat mass unchanged between weeks 5-9 PP - same for lactating vs non-lactating. 9 weeks PP fat mass was 1.5 (2.0)kg higher than before pregnancy. Pregnancy increased BMR by 18-20%. Fat stores did not change throughout the first 2 months PP even for lactating women.</td>
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<td>al (1989)</td>
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<td>Pipe et al (1979)</td>
<td>27 pregnant women</td>
<td>Body weight, total body H2O, total body protein, SF (biceps, triceps, sub-scapular, supra-iliac) measured 3X during pregnancy and 6-15 weeks PP.</td>
<td>Mean weight increase during pregnancy is 10.4 +/- .53 kg. Total body water increased by 7.2 +/- .48 kg during pregnancy. Body fat and excess H2O at PP fell to values which were similar on average to those measured in early pregnancy but FFM remained elevated. SF thickness fell after delivery to a mean value which was not significantly different from that obtained in early pregnancy. Fat cell diameter elevated.</td>
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<tr>
<td>Butte et al (1984)</td>
<td>45 lactating women</td>
<td>Milk production, dietary intake and body composition monitored for 4 months PP.</td>
<td>Overall mean energy intake was 2186 kcal/day. Weight PP was 64.6 (9.1) kg and was 59.3(10.5) kg at 4 months. Weight was lost at approximately 48 grams/day. Body fat averaged 28(7)% at one month and 26(8)% at 4 months by water displacement. Body fat averaged 28(5)% PP to 27(5)% at 4 months. Energy intake decreased significantly over the 4 months of lactation. Triceps and biceps SF did not change significantly. Supra-iliac, sup-scapular and sum of SF decreased significantly.</td>
<td>No control group. Activity levels were not assessed.</td>
</tr>
<tr>
<td>Lovelady et al (1990)</td>
<td>8 exercising and 8 sedentary BF women</td>
<td>RMR, VO2 max, plasma prolactin, cortisol, insulin and body composition measured. Each subject completed a 3 day dietary record, physical activity and milk volume.</td>
<td>Exercising women differed significantly from control subjects in VO2 max (46.4 vs 30.3 ml.kg.min), % body fat (21.7 vs 27.9%), total energy expenditure (3169 vs 2398 kcal/day) and intake (2739 vs 2051 kcal/day). No difference between groups in plasma hormones or milk energy, lipid, protein or lactose content. Exercise subjects tended to have higher milk volume and energy output in milk (538 vs 494 kcal/day). No adverse effect of vigorous exercise on lactational performance. Fat and energy concentrations of breast milk were significantly greater in women with larger triceps SF. Prolactin increased 19-398% from exercise.</td>
<td>No non-lactating control group</td>
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<td>Dusdieker et al (1994)</td>
<td>33 healthy BF women</td>
<td>Restricted mean energy intake to 538 kcal/day below the mean daily baseline intake of 2303(592)kcal.</td>
<td>22 women completed the 10 week study, losing a mean of 4.8(1.2)kg. Sum of 3 maternal SF (triceps, sup-scapular, supra-iliac), waist and hip measurements were significantly smaller at study completion. Modest dieting does not adversely affect quality or quantity of milk.</td>
<td>No control group. Did not control for activity levels.</td>
</tr>
<tr>
<td>Butte et al (1985)</td>
<td>45 lactating women</td>
<td>Measured at 1,2,3,4 months PP. SF (triceps, biceps, supra-iliac, sub-scapular), weight and body density measured.</td>
<td>Biceps and triceps SF did not change significantly over 4 months. Measurements of supra-iliac and sub-scapular SF and the sum of SF decreased significantly over time. Weight decreased.</td>
<td>No control group. Did not assess caloric intake and activity levels.</td>
</tr>
<tr>
<td>Munson et al (1994)</td>
<td>85 mothers</td>
<td></td>
<td>Those who BF babies for more than 6 months lost 10 pounds during 1st year while non-BF lost 5 pounds. Milk-inducing hormone, prolactin, may increase appetite during first few months.</td>
<td>No dietary or activity control</td>
</tr>
<tr>
<td>Atalah et al (1983)</td>
<td>95 BF 39 non BF</td>
<td>Measured weight, mid arm circumference, food intake at monthly intervals</td>
<td>Both groups showed non-significant and slight changes in weight and body composition. Only 10% of mothers showed weight losses above 4 kg. Weight losses significantly higher in obese and overweight women. Arm circumference and SF showed same trend. Suggests that FAO/WHO recommendations for dietary intake (2700 kcal) are too high.</td>
<td>No dietary or activity control</td>
</tr>
<tr>
<td>Thomson et al (1970)</td>
<td>23 BF 32 non BF</td>
<td>Energy values of diets determined by 7 day weighed survey.</td>
<td>Lactating mothers took on average, 591 kcal/day more than non-lactating. Activity levels of 2 groups the same.</td>
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<tr>
<td>Madhavaped dl et al (1992)</td>
<td>8 lactating poor income Indian women</td>
<td>Energy intake, expenditure, BMR, milk ingested by infants measured.</td>
<td>Mean body weights of mothers at end of 6 months similar to initial month of lactation. Only 1-2 kg body weight lost during 18 months BF. Energy intakes similar in BF and non-BF. Women with higher body weight lost more weight. Energy cost of lactation calculated to be 549 kcal/day. Activity levels low in initial month and then increase by 6 months PP.</td>
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<td>Dewey et al (1994)</td>
<td>33 sedentary BF women - 18 exercise, 15 non-exercise</td>
<td>Energy expenditure, dietary intake (by tape recorder), body composition, volume and composition of breast milk, MaxVO2, prolactin was assessed at 6, 8, 12, 18, 20 weeks PP. Exercise program consisted of supervised aerobic exercise (60-70% of HR reserve) for 45 minutes, 5X/wk for 12 weeks.</td>
<td>Women in exercise group expended about 400 kcal/day during the exercise sessions but compensated for this energy expenditure with a higher energy intake than that recorded by the control women (2497 vs 2168) MVO2 increased by 25% in the exercising women and by only 5% in the control women. There were no significant differences between the 2 groups in maternal body weight or fat loss, the volume or composition of the breast milk, the infant's weight gain or maternal prolactin levels during the 12 week study. No adverse effect on lactation.</td>
<td>No sedentary non-breastfeeding control group.</td>
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<tr>
<td>Villalpando et al (1992)</td>
<td>30 lactating Otomi Indian women</td>
<td>Anthropometry, body composition and dietary intake taken at 4 and 6 months PP</td>
<td>Caloric intake 1708 kcal/day (60% of recommended intake). Milk production negatively correlated with maternal body fat. Energy and fat concentration in milk positively related to weight, BMI, body fat, but not correlated to dietary intake</td>
<td>No control group. Did not control activity levels.</td>
</tr>
<tr>
<td>Guillermo-Tuzzon et al (1992)</td>
<td>40 Poor, rural Philippine BF (&gt; 3months) women.</td>
<td>Collected data on initial body weight &amp; fat, weight gain, BMR, weight, SF, energy intake, physical activity level. Measurements taken 6, 12, 18, 24, 30 weeks PP. by R.A. who stayed 14 hrs./day.</td>
<td>No difference in BMR or energy intake throughout lactation period. Physical activity increased significantly from 6 weeks to 30 weeks. Body weight and body fat decreased.</td>
<td>No control group.</td>
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Breastfeeding Frequency

Quandt et al (1983) found that declining fat area was associated with shorter and more frequent feeds. This suggest that as prolactin levels increase with lactation, the LPL-suppressive effects and lipolytic effects in adipose tissue, associated with prolactin are increased. This suggests that shorter, more frequent feedings will promote greater reduction in lower body fat. Quandt has proposed 2 mechanisms by which this may occur:

a) "Mediation by prolactin levels of gonadal hormone production. Serum prolactin levels in nursing women are inversely proportional to levels of estrogen and progesterone. The level of progesterone, in turn, has been found to be positively related to fat deposition in human females. Thus, women who nurse frequently, should be subject to greater suppression of ovarian hormone production, therefore, less disposed to deposit fat in body stores than women who nurse infrequently".

b) Mediation by the activity of the enzyme LPL, which is responsible for the hydrolysis and uptake of plasma TG into various kinds of tissue.

Dewey et al (1993) found that breastfeeding frequency and total time breastfeeding were both related to weight loss in breastfeeding mothers from 6-12 months. This suggests that if lactation is infrequent or does not occur, prolactin
levels fall rapidly, resulting in a return to the pre-pregnancy pattern of adipose tissue deposits and a greater likelihood that adipose tissue will be maintained.

These results suggest that breastfeeding frequency and total amount of time breastfeeding need to be assessed when examining this area.

**Caloric Intake**

Kramer et al (1993) discovered that the breastfeeding group consumed 462 kcal more per day. Manning-Dalton et al (1983), Naismith et al (1973), Brewer et al (1989), Sardusksis et al (1988), and Thomson et al (1970) confirmed these results. This suggests that breastfeeding increases the appetite. This is likely as Madhavapeddi et al (1992) found that the energy cost of lactation in 8 lactating poor income Indian women to be 549 kcal/day. Others have found it to be as high as 700 kcal/day. This energy must be supplied and thus, appetite is increased to ensure optimal levels of energy depots. These results may also suggest that non-breastfeeding women are more likely to restrict caloric intake. Breastfeeding women are usually not likely to diet for risk of inhibiting milk production and breast milk composition even though Dusdieker et al (1994) found that modest dieting does not adversely affect quality or quantity of breast milk. Naismith et al (1973) found 11 out of 20 formula feeding subjects were dieting.
Furthermore, Dugdale et al (1989) found that changes in body weight and skinfolds were influenced by the maternal desire to lose weight. Dieting must therefore, be considered as a factor affecting results. Many studies did not assess caloric intake or dieting and this is an obvious limitation to interpreting results.

Activity Levels

Manning-Dalton et al (1983) found that maternal activity was low during breastfeeding. Lovelady et al (1993) confirmed these results. This suggests that perhaps prolactin plays a role in suppression of activity levels. It may also suggest that breastfeeding women may be less able to leave the child for an exercise session. It can also be suggested that breastfeeding may be more exhausting than formula feeding because the mother may be forced to get up at regular intervals throughout the night to feed her infant, whereas, mothers who feed their infants formula, may be able to rely on their partner or someone else to share the task of feeding the infant. Therefore breastfeeding may leave women with less energy for maternal activity.

Thomson et al (1970), Kramer et al (1993) and Sadurskis et al (1988) all found that levels of activity during lactation did not change from pre-pregnancy levels.
The reasoning for contradicting results is unknown but probably a result of different tools for assessing activity levels.

Madhavapeddi et al (1992) found that activity levels were low in initial months postpartum and then increased by 6 months postpartum. Guillerno-Tauzon et al (1992) found a similar pattern finding that physical activity increased significantly from 6 weeks postpartum to 30 weeks postpartum. This suggests a prolactin relationship to activity levels. As prolactin concentrations are high during the initial weeks of lactation, the desire to be active may be lower. However, as prolactin levels drop in the remaining weeks of lactation, the suppressive effect to activity levels is removed and women will become more active. It may also suggest that as the infant gets older and becomes less dependent, the infant may sleep longer throughout the night allowing the mother more sleep and therefore, increasing her energy levels.

Many studies did not assess activity levels and this is an obvious limitation to interpreting results.

Parity Status

Harrison et al (1975) discovered significant declines in skinfolds with parity status. Dewey et al (1993) confirmed these results finding that greater parity was associated with greater weight loss. This may suggest that prolactin may be affected by parity status. Or perhaps, the women with greater parity status are also older
weight to lose. Perhaps, estrogen levels are lower in the older women indicating a greater ability to mobilize fat. Adair et al (1983) confirmed these suggestions, discovering that patterns of weight change during lactation in the first child were very similar to the pattern in the second child; however, it was found that greater weight loss occurred in the second lactation period.

However, Brewer et al (1989) found that primiparous women lost more weight during early postpartum months. Older multi-parous women lost more weight from 3–6 months. Potter (1991) confirmed these findings, reporting that primiparae appear to lose more weight and show greater body fat losses by 3 months postpartum that multiparae women.

The relationship between parity status and the reduction of fat during lactation is unknown. It is obvious that parity status needs to examined when researching this area.

Maternal Weight and Height

Dewey et al (1993) found that greater maternal height and weight was associated with greater weight loss. Manning-Dalton et al (1983) discovered that the women with the largest net weight gain in pregnancy lost the most weight. Dugdale et al (1989) found that changes in body weight and skinfolds were influenced by the
initial postpartum BMI of the women. Adair et al (1983) found that mothers who lost weight tended to be fatter at the beginning of lactation. Brewer et al (1989) also discovered that higher postpartum weight was associated with greater weight losses. Madhavapeddi et al (1992) discovered that women with higher body weight lost more weight. Atalah et al (1983) also found that weight losses were significantly higher in obese and overweight women. These results suggest that women who were fatter pre-pregnancy and women who had gained more weight during pregnancy may have had more weight to lose and therefore, reported a higher absolute weight loss.

Interestingly, Brewer et al (1989) found that greater weight losses were observed in mothers with lower pre-pregnancy weight. This may perhaps support set-point theory and genetic control. It may also suggest that these mothers were more motivated to attain their previous “thinner” physiques.

These results suggest that absolute weight change during the postpartum lactation period can not be the only measurement to assess the relationship between weight loss and breastfeeding. Instead, changes relative to pre-pregnancy weight and changes relative to weight gained during pregnancy need to be assessed also.
Section 4: Exercise During Lactation

Most of the research concerned with exercise during lactation has focused on the effects on milk production and composition. As yet, no study has examined specifically how exercise affects the relationship between lactation and the reduction of fat, particularly, lower body fat.

Dewey et al (1994) examined 33 sedentary breastfeeding women. The subject sample was split into an exercise group and a non-exercise group. It was found that the women in the exercise group expended about 400 kcal/day during the exercise sessions but compensated for this energy expenditure with a higher energy intake than that recorded by the control women (2497 vs 2168 kcal/day). VO2max increased by 25% in the exercising women and by only 5% in the control women. No significant differences were found between the 2 groups in maternal body weight or fat loss and no adverse effects on lactation were found. This suggests that the exercising women were able to eat more and still experience fat losses.

Lovelady et al (1990) found that 8 exercising breastfeeding women had a greater VO2 max, smaller percentage body fat, greater total energy expenditure and greater caloric intake than a non-exercising breastfeeding group. No adverse effect of vigorous exercise on lactation performance was found. Lovelady also stated that prolactin levels increased 19-398% during exercise. One would, therefore, expect a
larger prolactin response to lactation when exercise is introduced. Perhaps, this would cause a greater mobilization of fat, however, this effect could be offset by a greater caloric intake.

CONCLUSION

Based on evidence presented and discussed in this chapter, there is a substantial basis for the hypotheses that:

1. Breastfeeding, exercising women will have greater reductions of gluteo-femoral fat compared to abdominal fat
2. Breastfeeding, exercising women will reduce their body weight and body fat to pre-pregnancy levels
3. Breastfeeding, exercising women will increase their VO2max
4. Breastfeeding, exercising women will experience a reduction in BMD and BMC
CHAPTER 3: METHODS AND PROCEDURES

SUBJECTS

Selection Criteria

Subjects were selected based on eligible reproductive state (late pregnancy or earlier than 1 month postpartum), age range (non-adolescent), infant feeding status (breastfeeders), smoking status (non-smoker), weight gain during pregnancy (weight gain between 25-50 pounds) and medical status (without medical or obstetrical complications and not presently taking medications).

Exclusion Criteria

Exclusion criteria included a) age less than 18 b) medical or obstetrical complications c) greater than 1 month postpartum d) presently taking medications e) medical or obstetrical complications f) smoker g) formula feeding h) pregnancy weight gain less than 25 pounds or greater than 50 pounds.

Recruitment

Subjects were recruited by means of bulletins posted in the Vancouver Women's hospital, local physician's offices and The Fitness Group health club.

Bulletins enabled self-selection by provision of eligible reproductive state, age range, infant feeding status, smoking status, weight gain during pregnancy and medical
status. An additional source of subjects was by the recommendation of individuals already participating in the study.

Subjects were promised a complete set of their personal results in exchange for participation. Upon expressing interest in the study, individuals were mailed an information package and consent form (Appendix A). Having been informed in writing of a) purpose of the study b) the nature and extent of their prospective participation c) explanations of all testing procedures d) potential risks and discomforts involved e) the name, phone number and address of the author in the event of any questions or complaints and f) their right to deny consent and/or withdraw from the study at any time, subjects then provided their written, voluntary consent and completed a screening questionnaire (Appendix B). The screening questionnaire assessed, by self report, the status for intent of infant-feeding practice, intent to exercise, age, presence of medical or obstetrical complications, present reproductive state, expected date of birth, smoking status, pre-pregnancy weight, and parity status. All forms were returned by mail or by hand to the author who then contacted subjects by telephone regarding their further participation. It should be noted that in an essentially observational study such as this, where no experimental manipulation of variables occur, groups must naturally be formed according to inherent properties of individuals.
Research protocol was approved by the appropriate University of British Columbia Committee on Research Involving Human Subjects and the St. Paul's Hospital Ethics Committee for Human Experimentation.

STUDY SETTING

This study was performed in Vancouver, B.C., a large metropolitan city with a population approximating 500,000. The city records approximately 10,000 deliveries each year with 80-90% of the women choosing to breastfeed.

EXPERIMENTAL DESIGN

The study is longitudinal and descriptive in nature. There was no true manipulation of the independent variable (exercise) upon the dependent variables (maternal weight, maternal fat and fat deposition). Instead, dependent variables were analyzed for differences in subjects from the pre to post study period. Measurements included maternal weight, DXA estimation of total body fat and fat %, DXA analysis of regional fat distribution, skinfold and girth measurements, VO2max and DXA BMC, BMD and LTM.

The possibly confounding effects of certain variables on the dependent variables were examined. These variables included parity status, caloric intake,
infant feeding patterns, pre-pregnancy weight and pregnancy weight gain.

Maternal activity was also monitored.

**PROCEDURES and INSTRUMENTATION**

**Breastfeeding:**

Subjects were instructed to exclusively breastfeed (only breastmilk allowed) for at least 4 months postpartum. However, this study accepted subjects who “almost exclusively breastfed” (also fed vitamins, minerals, water or juice to their infants).

**Exercise Protocol:**

Subjects were instructed to exercise aerobically 4x/week for 40 minutes each session throughout the entire study. They were instructed to maintain an intensity level of 60-70% of their maximum heart rate or at a perceived exertion level of 5-6/10. The activities suggested to the subjects were running, walking, stairclimbing, bicycling or fitness classes. Subjects were instructed to stay within the parameters of the study as much as possible. They were instructed that levels below or above the protocol will affect study results.

**Anthropometric Measurements**

All body composition measures were performed by the author at St. Paul’s Hospital in Vancouver, B.C. at month 1 and month 6 postpartum. Prior to embarking upon this study, the author received training in anthropometric
measurements according to protocol of the International Society for the
Advancement of Kinanthropometry (ISAK). Data was collected and recorded on
data collection forms (Appendix C). Subjects were identified by name and exercise
status. Subjects wore appropriate exercise clothing (short tights and bra-top) and
were instructed to be in a post-absorptive state. When possible, subjects voided
prior to commencement of the anthropometric procedures. Subjects were advised
in advance to avoid excessive sweating, ingestion of large quantities of water, or very
salty foods prior to measurements; it was emphasized that a 'normal' state of
hydration was required for valid assessment of weight, girths and skinfold
measurements. Subjects were asked to avoid caffeine, drugs or alcohol 24 hours
prior to testing. They were also asked to avoid exercising 24 hours prior to testing.

GIRTHS:

Girths were measured with a steel tape calibrated in centimeters with millimeter
graduations. The tape was non-extensible with a stub before the zero line. All
measures were completed in duplicate to the nearest millimeter with a third reading
taken if there was a discrepancy between the first and second measurement of .5cm
or more. Mean values were taken as the 'true' value. By convention, all subjects
were assessed in the standard anatomical position.
Measurements were taken at the following defined sites. The thigh measurements were taken on the right side of the body.

**Waist:** Minimum waist circumference taken where the waist is best defined, approximately 1/2 way between the costal border and iliac crest. Where a well defined waist is not apparent, circumference taken halfway between the manerbrum sterni and umbilicus.

**Abdominal:** An umbilical circumference measurement taken at the level of the umbilicus.

**Lower Abdominal:** A sub-umbilical circumference measurement taken below the umbilicus approximately 5cm at the greatest anterior protuberance.

**Maximal Hip:** Obtained at the level of the greatest posterior protuberance.

**Proximal thigh:** Obtained at the level just below the gluteal line or at the arbitrary joining of the gluteal muscle protuberance with the thigh.

**Mid-thigh:** Obtained halfway between the gluteal line and the proximal point of the patella.

**Waist-Hip ratio:** The waist measurement was divided by the hip measurement to represent a measurement of regional fat distribution.

**Waist-Thigh ratio:** The waist measurement was divided by the thigh measurement to represent a measurement of regional fat distribution.
Measurements were taken at the following defined sites. The thigh measurements were taken on the right side of the body.

**Waist:** Minimum waist circumference taken where the waist is best defined, approximately 1/2 way between the costal border and iliac crest. Where a well defined waist is not apparent, circumference taken halfway between the manerbrium sterni and umbilicus.

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**Mid-thigh:** Obtained half way between the gluteal line and the proximal point of the patella.

**Waist-Hip ratio:** The waist measurement was divided by the hip measurement to represent a measurement of regional fat distribution.

**Waist-Thigh ratio:** The waist measurement was divided by the thigh measurement to represent a measurement of regional fat distribution.
Abdominal: The caliper reading when applied one cm. inferior to the left thumb and index finger raising a vertical fold which is 5cm lateral to and at the level of the mid-point of the navel.

Front thigh: The caliper reading when applied one cm. distally to the left thumb and index finger raising a fold on the anterior of the right femur when the leg is flexed at an angle 90 degrees at the knee by placing the foot on a box. The mid thigh position for the measurement is the estimated half-distance between the inguinal crease and the anterior patella.

Rear thigh: The caliper reading when applied one cm. distally to the left thumb and index finger raising a fold on the posterior of the right femur when the leg is flexed at an angle 90 degrees at the knee by placing the foot on a box. The mid thigh position for the measurement is the estimated half-distance between the inguinal crease and the anterior patella.

Sum of 4 SF: The 4 skinfold measurements were added to give an indication of lower body and trunk fatness.

WEIGHT:

Weight was determined using a hospital scale and recorded to the nearest .1kg. Subjects were weighed in their exercise gear (short tights, bra tap) wearing no shoes.
HEIGHT:

The subject stood erect and barefoot against a vertical wall with heels together and arms relaxed at sides. The measurement was taken as the maximal distance from the floor to the vertex of the head.

DXA TOTAL BODY FAT, FAT%, REGIONAL FAT DISTRIBUTION BMC, BMD AND LTM

Bone mineral content, bone mineral density, % body fat and regional fat deposition were calculated by a registered technician at St. Paul's Hospital using a Norland DXA machine. The DXA machine was calibrated daily. Each subject rested supine on the DXA Norland machine for approximately 25-30 minutes while a total body scan was taken. The technician ensured that each subject's body position was the same for both the pre and post study scan. All subjects, excluding one, were measured by the same technician.

Aerobic Capacity Testing:

VO2max was estimated at month 1 and month 6 postpartum using the Submaximal Ross Treadmill Protocol. The protocol was as follows:
<table>
<thead>
<tr>
<th>STAGE</th>
<th>MINUTES</th>
<th>MPH</th>
<th>% GRADE</th>
<th>OXYGEN COST</th>
<th>MET</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0-3</td>
<td>3.4</td>
<td>0</td>
<td>14.9</td>
<td>4.25</td>
</tr>
<tr>
<td>II</td>
<td>3-6</td>
<td>3.4</td>
<td>3</td>
<td>18.4</td>
<td>5.27</td>
</tr>
<tr>
<td>III</td>
<td>6-9</td>
<td>3.4</td>
<td>6</td>
<td>22.0</td>
<td>6.29</td>
</tr>
<tr>
<td>IV</td>
<td>9-12</td>
<td>3.4</td>
<td>9</td>
<td>25.6</td>
<td>7.31</td>
</tr>
<tr>
<td>V</td>
<td>12-15</td>
<td>3.4</td>
<td>12</td>
<td>29.2</td>
<td>8.33</td>
</tr>
<tr>
<td>VI</td>
<td>15-18</td>
<td>3.4</td>
<td>15</td>
<td>32.7</td>
<td>8.73</td>
</tr>
</tbody>
</table>

\[ \text{VO2Submaximal (ml/kg.min)} = \left\{ (75 + (6 \times \% \text{ grade})) \times (\text{mph}/60) \right\} \times 3.5 \]

\[ \text{VO2Maximal (ml/kg.min)} = 1.74 \times \text{VO2Submaximal at target heart rate (85% of HrMax Range)} \]

Subjects were instructed in advance to avoid excessive sweating, ingestion of large quantities of water, or very salty foods prior to the treadmill test; it was emphasized that a 'normal' state of hydration is required. Subjects were asked to avoid caffeine, drugs or alcohol 24 hours prior to testing. They were also asked to avoid exercising 24 hours prior to testing. The aerobic capacity testing occurred at The Fitness Group in Vancouver, B.C.

**Caloric Intake**

Caloric intake was assessed and calculated at 1 month, 4 months and 6 months postpartum with a 3day/24hour food recall method using a computer software program (FoodSmart). Two weekdays and one weekend were monitored.

**Activity Levels**

Subjects completed an activity log throughout the entire study that monitored exercise frequency, duration and intensity.
Infant Measurements

At birth, month one postpartum and month six postpartum, subjects had their physicians measure their infants' weight, height and head circumference.

Infant Feeding Patterns

Infant feeding practices were assessed at one month and six months postpartum with a 3day/24hour infant-feeding recall method. Two weekdays and one weekend were monitored.

STATISTICAL ANALYSIS

The primary null hypotheses to be tested were:

1. There is no difference between the amount of body fat lost from the gluteo-femoral region compared to the abdominal region in breastfeeding, exercising women

2. Breastfeeding, exercising women will not return to their pre-pregnancy weights

3. There is no difference between the VO2max at month one postpartum and month six postpartum in breastfeeding, exercising women

4. There is no difference between the BMC and BMD at month one postpartum and month six postpartum in breastfeeding, exercising women
The minimal acceptable level of significance is .05. Alpha is therefore 0.05 and risk of type I error is 5%.

Dependent measurements that were given primary importance are as follows:

\textbf{WHRatio}: Waist-Hip ratio

\textbf{WthighRatio}: Waist-Thigh ratio

Individual girth measurements from the abdominal and gluteo-femoral region

\text{Sum of Girths} = \text{sum of 6 trunk and lower body girth measurements}

Individual skinfold measurements from the abdominal and gluteo-femoral region

\text{Sum of skinfolds} = \text{sum of 4 trunk and lower body SF}

\text{Weight} = \text{absolute weight change from 1 month PP to 6 months PP}

\text{DXA Fat} = \% \text{ body fat measured by DXA}

\text{DXA Total Body Fat} = \text{Total fat grams measured by DXA}

\text{LegDXA} = \text{Total leg fat measured by DXA}

\text{AbdDXA}: \text{Total abdominal fat measured by DXA}

\text{TrunkDXA}: \text{Total trunk fat measured by DXA}

\text{VO2max}: \text{Estimated maximal volume of oxygen}

A descriptive assessment of caloric intake, BMD, BMC, LTM, maternal activity levels, infant feeding patterns and infant size measurements were undertaken. Trends and differences will be discussed.

Paired t-tests were performed on all dependant variables. Correlations were calculated to examine relationships between variables.
CHAPTER 4: RESULTS

4.1: Sample Characteristics

Descriptive characteristics of the study sample are presented in Table 4-1. Subjects who were delivering their first child made up 72.7% of the study sample (8 subjects) while 18.2% of the subjects (2 subjects) were delivering their second child and one subject was delivering her third child.

<table>
<thead>
<tr>
<th>Table 4-1 Clinical characteristics of the study population</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>PARITY STATUS</td>
</tr>
<tr>
<td>HEIGHT</td>
</tr>
<tr>
<td>PRE-PREGNANCY WEIGHT</td>
</tr>
<tr>
<td>PREGNANCY WEIGHT GAIN</td>
</tr>
<tr>
<td>WEIGHT AT DELIVERY</td>
</tr>
</tbody>
</table>

All of the subjects involved had exercised prior to pregnancy and during pregnancy; however, all subjects reported that the intensity, frequency and duration of their exercise program during pregnancy was reduced. The average pregnancy weight gain of the subjects (15.6kg) is within the range recommended by the Institute of Medicine (1990) suggesting that exercise throughout these subjects' pregnancies did not cause a low pregnancy weight gain.

It should be noted that it was the original intent of the study to examine both an exercising and a non-exercising group. However, during the recruitment stage, problems with recruiting non-exercising, breastfeeding subjects surfaced. The
problems arose for a variety of reasons. It appears that a mother who chooses to breastfeed tends to more health conscious and is therefore more likely to exercise. Also, this particular study was conducted in a middle-upper income area which also dictates the people living in this area are more educated and therefore, more likely to be health conscious and to exercise. Subjects volunteering for this particular study refused to be involved when asked to participate in the non-exercising subgroup. As a result, the focus of the study was changed mid-way through subject recruitment to involve only exercising subjects and thus, suffer the problems of not involving a control group. For future studies, recruitment from lower-middle income areas may promote better success and a stronger study.

4.2: Compliance and Dropout

A total of 14 subjects were recruited for the study, 11 of these 14 subjects completed the study (78.9%). One subject dropped out because she moved to Australia. The other two subjects dropped out because they developed complications with breastfeeding and were forced to start formula feeding.

Table 4-2 outlines subject compliance with the exercise protocol. Three subjects, (subjects 3, 10, 11) each missed a total of 3 weeks of exercise throughout the study due to colds and flues. One subject (subject 5) had a difficult time throughout the entire study due to severe mastitis. She reported that the infections
impacted her ability to keep up to a consistent level of aerobic exercise as required by the study. She reported that when she developed mastitis she experienced breast pain, headaches, aching joints, nausea and general flu-like symptoms. During these periods, she attempted to follow the study protocol and so, she resorted to walking only, but could not maintain an intensity that she was accustomed to or that the study demanded.

Table 4-2 Exercise compliance throughout the study

<table>
<thead>
<tr>
<th></th>
<th>MEAN</th>
<th>SD</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise/week</td>
<td>4.07 hours</td>
<td>.81 hours</td>
<td>3.0 hours</td>
<td>5.6 hours</td>
</tr>
<tr>
<td>Minutes/session</td>
<td>43.15 minutes</td>
<td>7.92 minutes</td>
<td>30 minutes</td>
<td>60 minutes</td>
</tr>
<tr>
<td>Intensity (RPE)</td>
<td>6.67</td>
<td>.49</td>
<td>5.9</td>
<td>7.3</td>
</tr>
</tbody>
</table>

All 11 subjects were able to breastfeed right up to the 4 month time-frame with most continuing on after 4 months (only 2 subjects had discontinued breastfeeding by month 6 postpartum). The strict criterion for 'Exclusive Breastfeeding', defined as introducing nothing but breast-milk, was adhered to by only 5 subjects. The other 6 subjects fed their infants liquid vitamins, in addition to breast-milk, and are therefore, categorized as 'Almost Exclusive Breastfeeding'. At month four postpartum, none of the mothers had introduced formula to their infants but, by month 6 postpartum, 4 subjects had begun to compliment breastfeeding with formula. At month 6, all subjects had introduced solids into their infants' diets.
Figure 4-1 displays the body weight changes that the subjects experienced prior to pregnancy, throughout pregnancy and during the postpartum intervention study. There was a significant difference between the subjects' self-reported weight prior to pregnancy and their weight at one month postpartum (60.7 ±5.3kg vs 66.2 ±6.2kg, p=.000). There was still a significant difference between the subjects' weight prior to pregnancy and their weight at 6 months postpartum (60.7 ±5.3kg vs 63.0 ±6.4kg, p=.003). A significant difference was found between the subjects' weight at month one postpartum and their weight at the completion of the intervention, 6 months postpartum (66.2 ±6.2kg vs 63.0 ±6.4kg, p=.003). Table 4-3 summarizes these findings:

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>MEAN</th>
<th>SD</th>
<th>2-TAIL PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE-PREGNANCY WEIGHT</td>
<td>60.7</td>
<td>5.3</td>
<td>.000</td>
</tr>
<tr>
<td>MONTH 1 PP WEIGHT</td>
<td>66.2</td>
<td>6.2</td>
<td></td>
</tr>
<tr>
<td>PRE-PREGNANCY WEIGHT</td>
<td>60.7</td>
<td>5.3</td>
<td>.003</td>
</tr>
<tr>
<td>MONTH 6 PP WEIGHT</td>
<td>63.0</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>MONTH 1 PP WEIGHT</td>
<td>66.2</td>
<td>6.2</td>
<td>.003</td>
</tr>
<tr>
<td>MONTH 6 PP WEIGHT</td>
<td>63.0</td>
<td>6.4</td>
<td></td>
</tr>
</tbody>
</table>
Figure 4-1: Maternal weight at pre-pregnancy, delivery, one month and six months postpartum
Table 4-4 displays the weight difference and the % change in weight from months one to month six. The subjects lost an average of 3.2 ±- 2.7 pounds from month one to month 6 postpartum (4.76% reduction).

Table 4-4: Maternal weight at month 1 and month 6 postpartum

<table>
<thead>
<tr>
<th>MEASUREMENT</th>
<th>MEAN (kg)</th>
<th>SD (kg)</th>
<th>DIFFERENCE (kg)</th>
<th>% CHANGE (%)</th>
<th>2 TAIL PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight 1</td>
<td>66.2</td>
<td>6.3</td>
<td>3.2 ±- 2.7</td>
<td>4.8 ±- 3.7</td>
<td>.003</td>
</tr>
<tr>
<td>Weight 2</td>
<td>63.0</td>
<td>6.4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.4: Girth Measurements

There was a significant difference between all girth measurements from month 1 to month 6 postpartum. There was however, no significant difference between the waist:hip ratio and the waist:thigh ratio at month one postpartum compared to month six postpartum (.773 +/- .03 vs .769 +/- .04, p=.426) and (1.34+/- .07 vs 1.32+/- .07, p=.06) respectively. Table 4-5 and Figure 4-2 summarize the results:

Table 4-5: Maternal girth measurements at month 1 and month 6 postpartum

<table>
<thead>
<tr>
<th>MEASUREMENT</th>
<th>MEAN (cm)</th>
<th>SD (cm)</th>
<th>DIFFERENCE (cm)</th>
<th>% CHANGE (%)</th>
<th>2 TAIL PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist 1</td>
<td>78.5</td>
<td>5.2</td>
<td>3.8 ±- 2.7</td>
<td>4.8 ±- 3.6</td>
<td>.002</td>
</tr>
<tr>
<td>Waist 2</td>
<td>74.8</td>
<td>5.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdomen 1</td>
<td>86.4</td>
<td>6.1</td>
<td>7.2 ±- 5.5</td>
<td>8.3 ±- 6.1</td>
<td>.001</td>
</tr>
<tr>
<td>Abdomen 2</td>
<td>79.2</td>
<td>7.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Abdomen 1</td>
<td>92.8</td>
<td>8.3</td>
<td>5.7 ±- 5.5</td>
<td>6.0 ±- 5.4</td>
<td>.006</td>
</tr>
<tr>
<td>Lower Abdomen 2</td>
<td>87.0</td>
<td>7.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip 1</td>
<td>101.6</td>
<td>6.8</td>
<td>4.4 ±- 3.6</td>
<td>4.2 ±- 3.2</td>
<td>.002</td>
</tr>
<tr>
<td>Hip 2</td>
<td>97.2</td>
<td>5.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal Thigh 1</td>
<td>58.6</td>
<td>4.3</td>
<td>2.0 ±- 1.6</td>
<td>3.5 ±- 2.6</td>
<td>.002</td>
</tr>
<tr>
<td>Proximal Thigh 2</td>
<td>56.6</td>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 4-2 Sum of 6 girths at month one and month six postpartum
4.5: Skinfold Measurements

There were significant differences in all skinfold measurements between month one and month six postpartum. Table 4-6 and Figure 4.3 summarize the results.

<table>
<thead>
<tr>
<th>MEASUREMENT</th>
<th>MEAN (mm)</th>
<th>SD (mm)</th>
<th>DIFFERENCE (mm)</th>
<th>% CHANGE</th>
<th>2 TAIL PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>IliacSF 1</td>
<td>20.6</td>
<td>8.7</td>
<td>5.3 +/- 4.7</td>
<td>26.6 +/- 20.4</td>
<td>.004</td>
</tr>
<tr>
<td>IliacSF 2</td>
<td>15.2</td>
<td>8.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AbdomenSF 1</td>
<td>23.5</td>
<td>8.9</td>
<td>8.1 +/- 4.8</td>
<td>35.9 +/- 15.5</td>
<td>.000</td>
</tr>
<tr>
<td>AbdomenSF 2</td>
<td>15.4</td>
<td>8.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front Thigh SF 1</td>
<td>25.6</td>
<td>4.6</td>
<td>5.1 +/- 2.7</td>
<td>20.4 +/- 11.2</td>
<td>.000</td>
</tr>
<tr>
<td>Front Thigh SF 2</td>
<td>20.5</td>
<td>5.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rear Thigh SF 1</td>
<td>23.7</td>
<td>4.6</td>
<td>3.9 +/- 2.6</td>
<td>17.4 +/- 13.1</td>
<td>.001</td>
</tr>
<tr>
<td>Rear Thigh SF 2</td>
<td>19.7</td>
<td>5.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum of SF 1</td>
<td>93.3</td>
<td>22.8</td>
<td>22.4 +/- 13.7</td>
<td>24.7 +/- 14.0</td>
<td>.000</td>
</tr>
<tr>
<td>Sum of SF 2</td>
<td>70.8</td>
<td>25.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.6: DXA Total Body Fat, Body Fat % and Regional Fat Distribution

There were significant differences in both DXA total body fat (21.2 +/- 5.5kg vs 19.0 +/- 5.5kg, p=.043) and DXA body fat % (31.6 +/- 5.6% vs 29.4 +/- 5.6%, p=.040)
Figure 4-3 Sum of 4 skinfolds at month one and month six postpartum
between month one and month six postpartum respectively. Table 4-7 and Figures 4.4 and 4.5 display these results. DXA regional fat distribution measurements showed significant differences in only abdominal fat (4.9 ± 1.5kg vs 4.2 ± 1.6kg, p=.029), leg fat (8.2 ± 2.2kg vs 7.2 ± 1.8kg, p=.004) and a composite measurement of Leg + Abdominal Fat (13.1 ± 3.5kg vs 11.3 ± 3.2kg, p=.007). Table 4-7 and Figures 4.6, 4.7 and 4.8 summarize these findings:

Table 4-7: DXA total body fat, fat % and regional fat measurements at month 1 and month 6 postpartum

<table>
<thead>
<tr>
<th>MEASUREMENT</th>
<th>MEAN</th>
<th>SD</th>
<th>DIFFERENCE</th>
<th>% CHANGE</th>
<th>2 TAIL PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fat 1 (kg)</td>
<td>21.2</td>
<td>5.5</td>
<td>2.2±3.1</td>
<td>10.1±12.1</td>
<td>.043</td>
</tr>
<tr>
<td>Total Fat 2 (kg)</td>
<td>19.0</td>
<td>5.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body Fat % 1</td>
<td>31.6</td>
<td>5.6</td>
<td>2.1±3.0</td>
<td>6.6±8.7</td>
<td>.040</td>
</tr>
<tr>
<td>Body Fat % 2</td>
<td>29.5</td>
<td>5.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head Fat 1 (kg)</td>
<td>.75</td>
<td>.05</td>
<td>.02+.05</td>
<td>2.6±6.2</td>
<td>.192</td>
</tr>
<tr>
<td>Head Fat 2 (kg)</td>
<td>.73</td>
<td>.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trunk Fat 1 (kg)</td>
<td>10.2</td>
<td>2.8</td>
<td>1.2±1.9</td>
<td>12.1±15.2</td>
<td>.063</td>
</tr>
<tr>
<td>Trunk Fat 2 (kg)</td>
<td>9.0</td>
<td>3.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AbdomenFat1 (kg)</td>
<td>4.9</td>
<td>1.5</td>
<td>.79±1.0</td>
<td>16.7±16.9</td>
<td>.029</td>
</tr>
<tr>
<td>AbdomenFat2 (kg)</td>
<td>4.1</td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arm Fat 1 (kg)</td>
<td>2.1</td>
<td>.67</td>
<td>-.02±.67</td>
<td>-.5±24.5</td>
<td>.932</td>
</tr>
<tr>
<td>Arm Fat 2 (kg)</td>
<td>2.1</td>
<td>.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg Fat 1 (kg)</td>
<td>8.2</td>
<td>2.2</td>
<td>1.0±.91</td>
<td>11.5±9.3</td>
<td>.004</td>
</tr>
<tr>
<td>Leg Fat 2 (kg)</td>
<td>7.2</td>
<td>1.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg+AbdFat 1 (kg)</td>
<td>13.1</td>
<td>3.5</td>
<td>1.8±1.8</td>
<td>13.3±10.8</td>
<td>.007</td>
</tr>
<tr>
<td>Leg+AbdFat 2 (kg)</td>
<td>11.3</td>
<td>3.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 4-4 DXA total body fat at month one and month six postpartum
Figure 4.5 DXA body fat percentage at month one and month six postpartum.
Figure 4-6 DXA abdominal fat at month one and month six postpartum
Figure 4-7 DXA leg fat at month one and month six postpartum
Figure 4-8: DXA leg + abdominal fat at month one and month six postpartum.
4.7: DXA Bone Mineral Content, Bone Mineral Density and Lean Tissue Mass

There were significant differences in BMD (.98 +/- .11g/cm vs .96 +/- .09g/cm, 
$p=.007$) and BMC (2.7 +/- .27kg vs 2.6 +/- .25kg, $p=.000$) between month one and 
month six postpartum respectively. Figures 4.9 and 4.10 display these results. An 
analysis of covariance was performed to determine if the changes in BMC and BMD 
were still significant after the values were adjusted for the postpartum weight 
change, however, the results did not change ($p=.0001$ and $p=.007$ respectively).

There was no significant difference in total lean mass ($p=.251$) between month one 
and month six postpartum. Table 4-8 summarizes these findings:

<table>
<thead>
<tr>
<th>MEASUREMENT</th>
<th>MEAN</th>
<th>SD</th>
<th>DIFFERENCE</th>
<th>% CHANGE</th>
<th>2 TAIL PROBABILTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMD 1 (g/cm)</td>
<td>.98</td>
<td>.11</td>
<td>.02 +/- .02</td>
<td>2.0 +/- 1.9</td>
<td>.007</td>
</tr>
<tr>
<td>BMD 2 (g/cm)</td>
<td>.96</td>
<td>.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMC 1 (kg)</td>
<td>2.7</td>
<td>.27</td>
<td>.1 +/- .05</td>
<td>3.6 +/- 1.6</td>
<td>.000</td>
</tr>
<tr>
<td>BMC 2 (kg)</td>
<td>2.6</td>
<td>.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Lean Mass 1 (kg)</td>
<td>42.4</td>
<td>2.4</td>
<td>.38 +/- 1.04</td>
<td>.9 +/- 2.5</td>
<td>.251</td>
</tr>
<tr>
<td>Total Lean Mass 2 (kg)</td>
<td>42.0</td>
<td>2.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.8: Aerobic Capacity

There was a significant difference in estimated VO2max (36.6 +/- 3.9 ml/kg.min vs 
41.6 +/- 6.6 ml/kg.min, $p=.004$) between month one and month six postpartum.

Table 4-9 and Figure 4.11 display these findings:
Figure 4-9 DXA Whole body BMD at month one and month six postpartum
Figure 4-10 DXA Whole Body BMC at month one and month six postpartum.
Table 4-9: VO2max at month 1 and month 6 postpartum

<table>
<thead>
<tr>
<th>MEASUREMENT</th>
<th>MEAN</th>
<th>SD</th>
<th>DIFFERENCE</th>
<th>% CHANGE</th>
<th>2 TAIL PROB.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO2max1</td>
<td>36.6</td>
<td>3.9</td>
<td>-5.0+/-.4.6</td>
<td>-13.6+/-.11.6</td>
<td>.004</td>
</tr>
<tr>
<td>(ml/kg/min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VO2max2</td>
<td>41.6</td>
<td>6.6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A closer look at the workloads at month one and month six postpartum at the 85% submaximal level is displayed in table 4-10:

Table 4-10: Submaximal workloads at month one and month six postpartum

<table>
<thead>
<tr>
<th>Subject</th>
<th>Month 1 Speed (mph)</th>
<th>Month 1 Incline</th>
<th>Month 6 Speed (mph)</th>
<th>Month 6 Incline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>3.4</td>
<td>15%</td>
<td>3.7</td>
<td>15%</td>
</tr>
<tr>
<td>Subject 2</td>
<td>3.8</td>
<td>15%</td>
<td>4.2</td>
<td>15%</td>
</tr>
<tr>
<td>Subject 3</td>
<td>3.4</td>
<td>12%</td>
<td>3.4</td>
<td>15%</td>
</tr>
<tr>
<td>Subject 4</td>
<td>3.4</td>
<td>15%</td>
<td>3.7</td>
<td>15%</td>
</tr>
<tr>
<td>Subject 5</td>
<td>3.4</td>
<td>12%</td>
<td>3.4</td>
<td>15%</td>
</tr>
<tr>
<td>Subject 6</td>
<td>3.4</td>
<td>12%</td>
<td>3.4</td>
<td>12%</td>
</tr>
<tr>
<td>Subject 7</td>
<td>3.8</td>
<td>15%</td>
<td>4.2</td>
<td>15%</td>
</tr>
<tr>
<td>Subject 8</td>
<td>3.4</td>
<td>11%</td>
<td>3.4</td>
<td>15%</td>
</tr>
<tr>
<td>Subject 9</td>
<td>3.4</td>
<td>10%</td>
<td>3.4</td>
<td>12%</td>
</tr>
<tr>
<td>Subject 10</td>
<td>3.4</td>
<td>12%</td>
<td>3.4</td>
<td>15%</td>
</tr>
<tr>
<td>Subject 11</td>
<td>3.4</td>
<td>15%</td>
<td>5.0</td>
<td>15%</td>
</tr>
</tbody>
</table>

4.9: Caloric Intake

Paired t-tests showed no significant differences between the amount of calories consumed by the subjects at month one, month four and month six postpartum.

Table 4-11 summarizes these findings:
Figure 4.11 VO2max at month one and month six postpartum
4.10: Infant Size Measurements

There were highly significant differences in all measurements of infant growth between months one and six postpartum. Table 4-12 displays the results.

Table 4-12: Infant size measurements at month one and six postpartum

<table>
<thead>
<tr>
<th>MEASUREMENT</th>
<th>MEAN</th>
<th>SD</th>
<th>Difference</th>
<th>% Change</th>
<th>2 TAIL PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>BABIES WEIGHT 1 (g)</td>
<td>4.9</td>
<td>.7</td>
<td>-2.7+1.7</td>
<td>-58.0+19.5</td>
<td>.000</td>
</tr>
<tr>
<td>BABIES WEIGHT 2 (g)</td>
<td>7.6</td>
<td>.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BABIES HEIGHT1 (cm)</td>
<td>57.5</td>
<td>2.9</td>
<td>-10.9+2.2</td>
<td>-19.1+4.5</td>
<td>.000</td>
</tr>
<tr>
<td>BABIES HEIGHT2 (cm)</td>
<td>68.4</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BABIES HEAD1 (cm)</td>
<td>39.4</td>
<td>2.3</td>
<td>-4.9+1.1</td>
<td>-12.5+5.6</td>
<td>.000</td>
</tr>
<tr>
<td>BABIES HEAD2 (cm)</td>
<td>44.3</td>
<td>1.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.11: Infant Feeding Patterns

There were significant differences in the infant feedings per day between month 1 and month 6 postpartum (p=.014) but no differences in the lengths of the feeding sessions (p=.092). Table 4-13 summarizes these findings.

<table>
<thead>
<tr>
<th>MEASUREMENT</th>
<th>MEAN</th>
<th>SD</th>
<th>Difference</th>
<th>% Change</th>
<th>2 TAIL PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEEDINGS/DAY 1</td>
<td>8.5</td>
<td>1.7</td>
<td>1.8+1.9</td>
<td>18.3+20.5</td>
<td>.014</td>
</tr>
<tr>
<td>FEEDINGS/DAY 2</td>
<td>6.7</td>
<td>1.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LGTH/SESSION1(min)</td>
<td>24.9</td>
<td>14.8</td>
<td>9.2+15.4</td>
<td>18.9+42.8</td>
<td>.092</td>
</tr>
<tr>
<td>LGTH/SESSIONS2(min)</td>
<td>15.8</td>
<td>3.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4-12: Menstrual Cycle

At the completion of the study, subjects were contacted to determine when they had started their menstrual cycle after the delivery of their infant. The information is presented in Table 4-14:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Onset of menstruation</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>7th month PP</td>
<td>Stopped BF at 6 months PP</td>
</tr>
<tr>
<td>Subject 2</td>
<td>9th-10th month PP</td>
<td></td>
</tr>
<tr>
<td>Subject 3</td>
<td>5th month PP</td>
<td></td>
</tr>
<tr>
<td>Subject 4</td>
<td>8.5th month PP</td>
<td>1 week after stopping BF</td>
</tr>
<tr>
<td>Subject 5</td>
<td>12.5th PP</td>
<td>Still BF at 12.5 months PP</td>
</tr>
<tr>
<td>Subject 6</td>
<td>Information not available</td>
<td></td>
</tr>
<tr>
<td>Subject 7</td>
<td>4th month PP</td>
<td>Still BF at 6 months PP</td>
</tr>
<tr>
<td>Subject 8</td>
<td>6th month PP</td>
<td>Still BF at 9 months PP</td>
</tr>
<tr>
<td>Subject 9</td>
<td>Information not available</td>
<td></td>
</tr>
<tr>
<td>Subject 10</td>
<td>Still hadn't started at 12th month PP</td>
<td>Still BF at 12 months PP</td>
</tr>
<tr>
<td>Subject 11</td>
<td>11th month PP</td>
<td>Menstruation started 3 weeks after stopping BF</td>
</tr>
</tbody>
</table>
4-13: Correlations

A further attempt was made to determine whether the changes in weight, total body fat or body fat percentage were dependent on the subjects' pre-pregnancy weight, their weight gain during pregnancy, the average amount of calories consumed, the intensity, frequency and duration of their exercise sessions or the changes in the size of their infants.

Correlation analysis showed that the weight gain during pregnancy was significantly correlated \( r = .85, p < .01 \) with the change in body weight from month 1 to month 6 postpartum, such that those women who gained the most weight during pregnancy also lost the most weight during the intervention. Figure 4-12 displays these findings. The weight gain during pregnancy was also significantly correlated to both the total fat change \( r = .73, p < .05 \) and the change in body fat percentage \( r = .62, p < .05 \) between months one and six postpartum. These results also suggest that those women who gained the most weight during pregnancy also lost the most fat and reduced their body fat percentage by the greatest amount. Figures 4-13 and 4-14 display these findings. However, there was no significant relationship between pre-pregnancy weight and the total weight and fat lost during the study period.
Figure 4-12 Graph of weight gain during pregnancy and weight change from month one to month six postpartum.
Figure 4-13 Graph of pregnancy weight gain and DXA fat change between months one and six postpartum
Figure 4-14 Graph of weight gain during pregnancy and DXA fat % change from month one to month six postpartum
There was a significant correlation between the difference in calories consumed over the intervention and the change in total body fat ($r = .71$, $p<.05$) and the change in body fat percentage ($r = .65$, $p<.05$) from month one to month six postpartum, therefore, suggesting that those women who lost the most body fat during the study were the subjects who were tending to eat more calories in month six compared to month one postpartum. Figures 4-15 and 4-16 demonstrate these findings. It is interesting to note, however, that there was no significant correlation between the difference in calories consumed and the change in total body weight from month one to month six postpartum. There was also no significant correlation between the average amount of calories consumed throughout the study and the weight and fat changes from month one to month six postpartum.

There was no significant correlation between the amount of weight and fat lost in the subjects to the size gain (height, weight, head circumference) in their infants.

There was no significant correlation between exercise intensity, frequency and duration and the changes in subject weight and fat from month one to month six postpartum.

There were no significant correlations between the parity status of the subjects and the change in body weight ($p=.526$), the change in total body fat
Figure 4-15 Change in calories and change in DXA body fat from month one to month six postpartum.
(p=.856) and the change in body fat percentage (p=.915) between months one and six postpartum.

There were strong correlations between the change in the sum of skinfolds and the change in DXA total body fat (r = .85, p< .01) and the change in DXA body fat percentage (r = .80, p< .01). Figures 4-17 and Figures 4-18 display these findings.

There were no significant correlations between the average amount of calories consumed throughout the study and the exercise frequency, duration and intensity.
Figure 4-17 Graph of changes in DXA total body fat and sum of SF between month one and six postpartum.
4-18 Graph of change in skinfolds and change in DXA total body fat % between months one to six postpartum

Change in DXA body fat % between months 1-6 PP (%)
CHAPTER 5: DISCUSSION

The primary purpose of this study was to examine the body composition changes over time in 11 breastfeeding/exercising women. The hypotheses stated that: a) breastfeeding, exercising women will have greater reductions of gluteo-femoral fat compared to abdominal fat  b) breastfeeding, exercising women will reduce their body weight and body fat to pre-pregnancy levels  c) breastfeeding, exercising women will increase their VO2max and d) breastfeeding, exercising women will experience a reduction in BMC and BMD.

This study has demonstrated that the breastfeeding, exercising subjects did lose a significant amount of weight, total body fat, total body fat %, lower body and trunk girths and skinfolds and lower body and trunk fat as measured by DXA and improved their MV02 between months one and six postpartum. However, the study did not demonstrate that the breastfeeding, exercising subjects lost more body fat from the gluteo-femoral region compared to the abdominal region. The study also did not demonstrate that breastfeeding, exercising women were able to return to their pre-pregnancy weights by 6 months postpartum. The following discussion will analyse the results and also compare them to available research in order to develop some conclusions and suggestions.
**Body Weight:**

During pregnancy, both in women and in animals, there is an increase in the weight of fat and lean tissues of the mother, quite apart from the products of conception, the uterus and related structures. The accepted explanation for this is that the mother is storing energy to support the energy demands of lactation. Pregnancy, however, is frequently cited as a cause of long-term weight gain with women frequently reporting a net weight gain as a result of pregnancy (Greene, 1988). Failure to lose the weight gained during pregnancy can lead to obesity (Tooke Crowell, 1995) and therefore, any actions to decrease the likelihood of excessive weight retention will enhance the health of the mother. It was hypothesized that breastfeeding, exercising women would return to their pre-pregnancy weights by six months postpartum. In the present study, at month one postpartum, the subjects’ weights were significantly higher than their pre-pregnancy weights suggesting that the weight of the fetus and the typical 2kg water lost in the first month postpartum did not completely account for the weight gain in pregnancy. The subjects were still carrying approximately 9% more body weight (5.5kg) compared to pre-pregnancy. By month one, none of the subjects had returned to their pre-pregnancy weight, whereas, many textbooks suggest that women, having gained an average of 25-30 pounds throughout their pregnancy, can
expect to return to their pre-pregnancy weights by week 4-6 postpartum (Tooke Crowell, 1995). These types of false expectations can lead women to become frustrated and discouraged with their attempts to return to their pre-pregnancy weights and figures too early. Olsen (1986), however, reported results similar to the present study, finding that only 28% of women had returned to their pre-pregnancy weights by 6 weeks postpartum. The subjects in the present study all had exercised throughout pregnancy and yet, this higher level of activity did not enable them to return to their pre-pregnancy weights any earlier than has been reported in other studies. As expected, results of this study found a significant difference in maternal weight between months one and six postpartum with the subjects losing an average of 3.2 ± 2.7kg (4.8% loss). However, results also reveal that there was still a significant difference between pre-pregnancy weight and the weight of the subjects after the exercise intervention, at month six postpartum. The subjects were still carrying on average 2.3kg more than before pregnancy. In fact, by month six postpartum, only one subject had reached her pre-pregnancy weight. It was expected that the exercise intervention and breastfeeding would be sufficient to return all subjects to their pre-pregnancy weights; however, this was not the case. The present study confirms Greene's (1988) findings which reported that women, who have had an average amount of weight gain during pregnancy, will retain
about 1kg after the birth of each child, above and beyond the 0.45kg per year
normally gained with age. Greene (1988) reported that women are heavier after
pregnancy than before pregnancy with at least one woman in ten retaining excessive
weight (>6.6kg). None of the present study’s subjects had retained excessive weight
(>6.6kg), which might suggest that the exercise intervention serves to prevent
excessive postpartum weight retention.

Kramer (1993) found that breastfeeding subjects at 6 months postpartum
were approximately 3% above their pre-pregnancy weight which is similar to the
present study’s subjects who were 3.8% above their pre-pregnancy weights at
month 6 postpartum. Kramer’s study also found that formula feeding subjects were
7.5% above their pre-pregnancy weight which is substantially higher than Kramer’s
and the present study’s breastfeeding subjects. These findings suggest that although
breastfeeding appears to return women to their pre-pregnancy weights more quickly
compared to formula-feeding, the added exercise intervention does not add a further
effect. Dewey et al (1994) confirmed that an exercise intervention was unsuccessful
in promoting a greater weight loss, finding that there was no significant difference
in maternal weight between exercising and non-exercising breastfeeding women,
however, Dewey et al (1993) did find that the average weight of breastfeeding
mothers was approximately 2.1kg lower than formula feeding mothers.
If we attempt to compare our weight-loss results to available research, difficulties surface. Studies that have examined weight loss during the postpartum period present conflicting results with some studies reporting that breastfeeding enhances weight loss while others find that there were no differences in weight loss between breastfeeding and formula feeding subjects. The inconsistency among results may be due largely to methodological differences among studies, such as the type of study population, definition of breastfeeding, maternal postpartum energy intake, maternal activity levels, anthropometric measurements taken and time of measurements. For example, Potter et al (1991) included in the lactating group anyone who breastfed for as little as 6 weeks postpartum.

The present study found an average weight loss of 3.2+-2.7kg in the breastfeeding, exercising women between months one and six postpartum. Other studies have found average weight losses in breastfeeding, non-exercising women from month one to month six postpartum of 1.4-3.4kg which is similar to the present study. It was expected that the exercising, breastfeeding women in the present study would lose substantially more weight than subjects who were just breastfeeding. However, it appears that the increased energy expenditure, as a result of the exercise protocol, did not increase weight loss any more than subjects who were only breastfeeding in other studies.
Some studies have displayed average weight losses in formula feeding women from month one to month six postpartum of 4.4kg (Naismith, 1973; Kramer, 1993) which is substantially greater than the breastfeeding subjects mentioned in the previous studies. This would suggest that formula feeding promotes a greater maternal weight loss postpartum. This may be the result of an increased likelihood of formula-feeding mothers to diet. For example, although Naismith (1973) found formula feeding mothers to lose substantially more weight, 11/20 of these subjects were aggressively dieting in order to return to their pre-pregnancy weights. Dusdieker (1994) found that breastfeeding subjects who dieted lost an average of 4.8±1.2kg by week 10 postpartum which is similar to the weight loss exhibited in some formula feeding women over a six month period. This supports the suggestion that perhaps, formula feeding women are more likely to diet whereas, breastfeeding women would be less likely to diet because they are instructed not to restrict caloric intake in order to maintain healthy milk volume and composition. It has been suggested that modest dieting does not adversely affect quality or quantity of milk and is necessary to return to pre-pregnancy weight.

It can also be suggested that there is a maternal mechanism which causes the body and its metabolism to be more efficient during breastfeeding in order to conserve more body weight for the purpose of milk production, thus, slowing down
the rate of weight loss. Women who breastfeed may also be, generally, more tired and drained from the process of breastfeeding and are, therefore, less likely to be active. In fact, prolactin levels have been demonstrated to cause a decrease in activity levels (Sadurskis, 1988). However, regular moderate to high intensity activity in the present study’s subjects still did not cause a substantially greater weight loss.

Dewey (1993) found no difference in weight loss between breastfeeding and formula feeding mothers from 1-3 months postpartum but found a highly significant difference from 3-6 months postpartum. Dewey suggested that women may need to breastfeed for longer than 6 months if they expect lactation to enhance fat loss. It has been suggested that the delayed effects of lactation on maternal weight are related to the influence of prolactin concentrations on appetite. In the first few months, prolactin levels are high which would lead to high energy intakes that would balance the high energy demands of lactation. Later in lactation, prolactin levels normally decline even though energy output in milk is still considerable. This would result in reduced appetite, relative to energy demands, and thus, greater weight loss. However, the present study found that weight loss was not correlated to caloric intake.
It is difficult to determine whether any of these effects are long-lasting because the majority of studies occur over a six month period or less. A longer study would indicate more enduring results. In addition, because there are so many factors affecting weight and fat loss during the postpartum period, any future attempts should control for all confounding variables in order to provide for more accurate generalizations.

We suggest that there could be a few explanations surrounding the smaller than expected weight and fat loss in the present subject’s study. Although, we found no relationship between caloric intake and fat or weight loss, it is well known that women have a tendency to under-report the amount of food consumed. Therefore, the women in the present study could have been consuming more calories as a result of the exercise protocol therefore, explaining the minimal weight and fat losses. There is also a possibility that because the exercise protocol was quite aggressive, the women may have used all their energy to adhere to the exercise protocol and, as a result, the rest of their daily spontaneous activity was reduced. This would have resulted in a daily activity output that would have been possibly the same as if they had not exercised.

There seems to be no conclusive evidence to suggest an expected weight loss during the lactating postpartum period or to suggest that breastfeeding women will
return to their pre-pregnancy weights any more quickly, less quickly or at the same rate of non-breastfeeding women. The author of the present study hypothesizes that weight loss during the lactating postpartum period is multi-factorial, similar to weight loss during any other period in a woman's life and therefore, weight loss during the lactating stage will be an individual experience based on a number of factors such as genetics, maternal activity levels, maternal metabolic rate, maternal caloric intake, infant size, infant feeding patterns and any other internal mechanisms present during the postpartum period that we are not aware of.

Many studies have suggested that weight loss during the lactating postpartum period is dependant on a number of variables. Some studies have found a correlation between the weight loss during the postpartum period and shorter, more frequent infant feeds (Quandt, 1983), parity status (Harrison, 1975, Brewer, 1989), pre-pregnancy weight (Dewey, 1993, Brewer, 1989), pregnancy weight gain (Manning-Dalton, 1983), and a desire to lose weight (Dugdale, 1989). The present study attempted a number of correlations in order to determine which variables affected the weight loss phenomenon.

Tooke-Crowell (1995) reported that women, who gained more weight during pregnancy, lost more weight in the postpartum period, although weight gains >15.7kg (35 pounds) can lead to significant weight retention at 6 months.
postpartum. In the present study, a positive relationship was found between pregnancy weight gain and the weight change from month one to month six postpartum, such that those women who gained the most during pregnancy also lost the most during the study. For instance, in the present study, the subject who gained the most amount of weight during pregnancy also lost the most weight during the study intervention. However, since she had more weight to lose, it would be expected that the weight loss would obviously be greater but this does not suggest that she had returned any more quickly to her pre-pregnancy weight. In fact, as Tooke Crowell (1995) reported, although subjects who gain more during pregnancy may lose more weight during the postpartum period, they may still be at risk for a greater postpartum weight retention. However, this is not supported by the present study's findings. The subject who gained the most weight during pregnancy was only 3.6kg above her pregnancy weight. There were four other subjects who had substantially more weight to lose than she did in order to return to their pre-pregnancy weights.

It has also been found in previous studies, that the weight and fat lost during the lactating postpartum period is dependant on pre-pregnancy weight. This suggests a set-point theory of weight loss which states that a certain quantity of body fat is homeostatically regulated for the individual and that those women, who
had a smaller pre-pregnancy weight, would have an easier ability to return to their pre-pregnancy weight. Tooke Crowell (1995) reported that women of low pre-pregnancy weights returned to their pre-pregnancy weights more quickly probably because of a higher metabolic rate and a greater desire to reach an ideal weight. However, the present study found no relationship between weight or fat lost and pre-pregnancy weight from months one to six postpartum.

The present study found no significant relationships between the weight loss during the study and the average amount of calories consumed over the study period, the difference in calories consumed from month one to month six postpartum, the size gain of their infants from month one to month six postpartum, the exercise frequency, duration or intensity and the parity status. This does not, however, suggest that these variables do not play important roles in weight loss during the postpartum period, instead, the results may have been inhibited by a small sample size and large variability within subjects. It is interesting to note, however, that the one subject who had gained weight during the study was also the only subject delivering her third child.

Girth Measurements:

It was expected that more body fat would be mobilized from the gluteo-femoral region compared to the abdominal region in the exercising, breastfeeding subjects.
Kramer (1993) found a 6.5% reduction in hip circumference in breastfeeding women by month six postpartum; however, the present study found only a 4.24% reduction which is even less than Kramer's formula feeding subjects who lost an average of 6% in hip circumference. In fact, the results of this study do not indicate a specialized reduction in gluteo-femoral fat for milk production. In fact, the largest change occurred at the abdominal and waist girths with a loss of 7.2 ±5.5cm (8.3% loss) and 5.7±55.3cm (6.0% loss) respectively. The proximal and distal thigh measurements experienced the lowest reductions at 2.0±1.6cm (3.5% loss) and 1.6±-2.0cm (3.0% loss) respectively. So, although a 5.2% reduction occurred in the sum of all girths, the majority of the difference in girths occurred at the level of the abdominal compared to the gluteo-femoral region. This is supported by a non-significant difference in waist-hip and waist-thigh ratio from month one to month six. If more fat was being lost from the gluteo-femoral region, the waist-hip and waist-thigh ratios would increase, but in fact, although not significantly different, the waist-hip and waist-thigh ratios actually drop suggesting more fat is lost from the abdominal region compared to the gluteo-femoral region.

**Skinfold measurements:**

It was expected that a greater drop in body fat would occur from the gluteo-femoral region which would be represented by a greater reduction in the thigh skinfolds.
compared to the abdominal skinfolds. The present study does not support this hypothesis, instead, finding greater reductions in the iliac skinfold (5.3 +\-4.7mm; 26.6% reduction) and the abdominal skinfold (8.1+\-4.8mm; 35.9% reduction) compared to the front thigh skinfold (5.1+\-2.7mm; 20.4% reduction) and the rear thigh skinfold (3.9+\-2.6mm; 17.4% reduction). However, this may suggest that since the present study’s subjects exercised throughout pregnancy, perhaps they distributed less body fat in their thighs and instead, deposited fat to a greater extent around the area in close proximity to the fetus. The author of this study has noted in her experiences with exercising, pregnant women that they seem to have a characteristic weight gain pattern. They often appear to gain substantially more weight around their abdominal region and if you examine them posteriorly it can be almost impossible to determine that they’re pregnant.

**DXA Total Body Fat and Body Fat %:**

It was expected that the subjects in the present study would lose a significant amount of body fat and total body fat %. This hypothesis was supported by finding a 10.1% reduction in total fat and a 6.6% reduction in body fat percentage; however, these results are difficult to interpret because there is no control group and all other studies have used skinfolds and other methods of determining body fat measurements. Sadurskis (1988) found a modest reduction of 1.7kg of body fat in
lactating mothers between months two and six postpartum and suggested that a serious shortage of food or physically heavy work would be required in order to cause a greater reduction of body fat. However, the present study, involving aggressive exercise 4x/week, only displayed a body fat loss of 2.2+-3.1kg, therefore, demonstrating that heavy exercise did not compound the relationship between breastfeeding and fat loss. Quandt (1983) found that declining maternal fat was associated with a breastfeeding pattern of short, frequent feeds and that a feeding frequency of more than 6 bouts per day is necessary to maintain elevated levels of prolactin and its fat-mobilizing effect. In the present study, the mothers fed their infants on average 8.5+-1.7x/day and 6.7+-1.3x/day at months one and six postpartum respectively. These subjects were therefore exposed to the fat-mobilizing effect of prolactin; however, the amount of body fat loss was not significantly different than any other breastfeeding studies.

There is no study, to the author's knowledge, that examined body fat in breastfeeding, exercising subjects using DXA. It has been suggested that DXA may become the next gold standard for body fat determination (Roubenoff, 1993) which makes this study a worthwhile contribution to the literature. The body fat measurements calculated by DXA are substantially higher than those values that are calculated by other methods suggesting that the universal body fat standards and
ideals may need to be reassessed. In the present study there were average differences of 6-7% between the higher body fat calculated by DXA and the values calculated using the Siri and Brozek formulas which are based on body density, not measured by DXA. Butte et al (1984) found that body fat, measured by water displacement, was 28+-7% at month one postpartum and 26+-8% at month four postpartum. The subjects in the present study were measured by DXA as 31.6+-5.6% body fat at month one postpartum and 29.5+-5.6% body fat at month six postpartum. These subjects were all very healthy and fit mothers who exercised throughout pregnancy and followed an aggressive exercise protocol and yet, the DXA fat measurements were substantially greater. The author suggests a reassessment of body fat measurement standards and protocols. The present study calculated the correlation between the sum of skinfolds and the DXA total body fat and the DXA fat percentage and found significant correlations of r=.85 and r= .80 respectively. Therefore DXA and skinfold measurements appear to be measuring similar directional changes in body fat; however, it needs to be determined which is more accurate and which provides the most information.

**DXA Regional Fat Distribution**

It was expected that a greater loss of body fat would occur from the gluteo-femoral region compared to the abdominal region during the study intervention to
serve the purpose of milk production. This hypothesis has not been supported by the girth and skinfold measurements examined in the present study. Other studies have used crude indicators of fat distribution such as triceps skinfold, WHR, thigh girth, hip circumference, or comparing a proximal to a distal girth or skinfold measurement. No other study has yet to examine regional fat distribution using DXA. Although other studies have reported poor precision in DXA regional fat distribution measurements reporting a 17.1% precision for the upper limbs and a 1.3% precision for the lower limbs (Drinkwater, unpublished), and a coefficient of variation of 2.0% for trunk fat % and a coefficient of variation of 3.6% for lower limb fat % (Pritchard, 1993), the results of this study are still worth reporting. Snead et al (1993) reported that only 55% of exogenous fat (lard that was placed over the body at different regions) was identified as fat when it was in the trunk region compared with 96% when it was positioned over the legs. These studies seem to suggest that we can be confident with the DXA regional fat results reported in the thigh region, less confident in the trunk area and the least confident in the arm fat. It appears that because the size and the amount of fat in the arm is much less compared to the thighs and trunk, DXA experiences difficulty when attempting to determine accurate and precise measurements in this area. The other major concern with DXA regional fat distribution is the values used to indicate fat regions.
DXA categorizes trunk fat as the fat contained in the area extending from the cervical vertebrae down to the pubis bone, including the pelvis but not including the femur. Therefore, DXA trunk fat includes abdominal and gluteal fat. DXA categorizes abdominal fat as the fat contained in the region extending from the bottom of the pelvis up to the lower ribs. The DXA abdominal fat measurement would therefore also include gluteal fat. The DXA thigh fat measurement only includes the leg as the measurement begins at the neck of the femur on a diagonal cut. Based on these DXA categories we cannot separate true abdominal fat from gluteo-femoral fat. The present study reveals large reductions in DXA leg fat (11.5±9.3% reduction) and DXA abdominal fat (16.7±16.9% reduction), but again, it is impossible to comment on these results because the values are not representing the regions correctly. It has also displayed a non-significant increase in arm fat which would indicate and support other findings of a redistribution of body fat; however, we cannot be confident of this result due to the errors in DXA’s ability to accurately assess arm fat. Manning-Dalton (1983) found larger changes in proximal compared to distal skinfold measurements indicating a preferential utilization of subcutaneous fat from the trunk which is supported by this study’s DXA regional fat measurements. It is suggested that the DXA categories for
regional fat distribution be re-evaluated because they do not represent and separate the true regions.

**DXA Bone Mineral Content and Bone Mineral Density:**

The present study supports other findings reporting a $2.0 +\pm 1.9\%$ drop in bone mineral density and a $3.6 +\pm 1.6\%$ reduction in bone mineral content in the subjects from month one to month six postpartum. Studies have demonstrated that as lactation advances beyond 3 months, there is a decrease in calcium absorption. This decline in intestinal calcium absorption is offset in lactating women by an increased loss of calcium from bone. These studies indicate that regardless of dietary calcium and/or vitamin D status, some bone loss ($2-3\%$ of bone calcium) occurs in lactating women. This loss in BMC and BMD is still significant even after you control for postpartum weight loss. However, there is no need for concern since other studies have shown that the bone measurements return to normal values once breastfeeding is discontinued (Kent, 1991; Kent, 1993; Dobnig, 1995). The loss in BMC and BMD may be explained through a comprehensive analysis of the onset of the postpartum menstrual cycle and the associated hormonal changes. In the present study 5 of the subjects began their menstrual cycle as soon as they stopped breastfeeding, 3 of the subjects started their menstrual cycle before they stopped breastfeeding and 1 breastfeeding subject had still not started her menstrual cycle at
1 year postpartum. The variability in these figures and the small subject sample makes it impossible to comment on any possible relationships.

**Aerobic Capacity:**

The exercise intervention was successful in increasing the aerobic capacity of the subjects by 13.6\(\pm\)11.6\% in their VO2max (36.6\(\pm\)3.9 vs 41.6\(\pm\)6.6ml/kg.min).

A close examination of the subjects’ submaximal workloads at month one and month six postpartum indicates that the women improved their fitness levels. Their VO2max values were greater both at month one and month six postpartum compared to Lovelady’s (1990) control subjects (non-exercising/non-breastfeeding) who exhibited a VO2max score of 30.3ml/kg.min. Dewey et al (1994) reported a 25\% VO2max increase in her breastfeeding exercising subjects which is a substantially greater increase compared to the present study, however, her exercise protocol was even more aggressive requiring a 45 minute aerobic session 5x/week. Dewey’s non-exercising, breastfeeding control subjects increased their VO2max by only 5\%, which is substantially less than the present study’s findings suggesting that the exercise protocol required by the present study was adequate to improve the subjects’ aerobic capacity. This is encouraging for postpartum women because with a higher aerobic capacity, they’ll experience greater energy and stamina, therefore helping them through the stressful, initial postpartum stage. Many of the subjects
reported to me that they found it difficult to adhere to the exercise protocol. They felt that if it wasn’t for the study, they would not be exercising as much as required by the study. They found that the long sleepless nights, lack of adequate child care and the disruptions that breastfeeding introduced were huge deterrents to exercise. Two of the subjects, who returned to work early postpartum, reported that they had a very difficult time trying to fit exercise into their busy schedule. They experienced extreme guilt after being away from their babies all day that they found it difficult to justify another hour away to get to the gym. These subjects were forced to be very creative in their methods of adhering to the study’s exercise protocol. One of the subjects walked to work in order to obtain the aerobic activity required. The other subject purchased a baby jogger and took the baby out for walks when she returned from work. The difficulties experienced by the subjects in this study suggest that mothers need to develop a postpartum plan to ensure they receive regular exercise.

Caloric Intake

The average calories reported in the present study of 2162±664 at month one, 2303±533 at month four and 2145±471 at month six postpartum are similar to caloric intakes reported in other breastfeeding studies; 2113±489 at ≤ weeks postpartum and 2029±482 at 30 weeks postpartum (Guillermo-Tuazon, 1992),
2055+\-435 at 6 months postpartum (Brewer, 1989), 2186 +\-463 at 4 months postpartum (Butte, 1984) and 2156 +\-576 at 3 months postpartum (Manning-Dalton, 1983). Some studies reported substantially higher caloric intakes in breastfeeding women; 2716kcal (Thomson, 1970) and 2930+\-106kcal (Naismith, 1973); however, the present study involved breastfeeding subjects who were exercising heavily and still, they did not approach these higher caloric intakes. The RDA of 2500kcal/day for breastfeeding, non-exercising mothers may be too high. One can also suggest that perhaps the women under-reported their food intakes.

It was expected that the subjects' caloric intakes would be less at month six than at month one or four postpartum, however, the present study found no significant difference between the amount of calories subjects consumed at month one, four or six postpartum. This suggests that the decreased prolactin levels that occur during the later stages of lactation did not reduce these subjects' appetites.

The present study confirms other studies' findings that report breastfeeding subjects consume a higher amount of calories than formula feeding mothers. Reported caloric intakes of formula-feeding mothers have varied from 1851+\-591 (Manning-Dalton, 1983) to 1453 +\-515 (Brewer, 1989) which are substantially lower than the calories consumed by this study's exercising, breastfeeding women. Kramer (1983) reported that breastfeeding women consume on average 462kcal
more per day and yet, still continue to lose body weight, therefore, suggesting that
the caloric demands of lactation are high. It has been reported that the daily caloric
demands of breastfeeding approximate 500-700kcal/day suggesting that
breastfeeding women can eat more and still lose body weight and fat. It was
expected that the added caloric expenditure of this study’s exercise protocol would
increase caloric intake, however, it appears that the added exercise did not increase
the subjects’ appetites any more compared to the non-exercising breastfeeding
subjects from other studies. This is supported further by a non-significant
correlation between caloric intake and exercise intensity, frequency and duration. It
is very interesting to note an unexpected positive correlation was found between the
difference in calories consumed from month one to month six postpartum and the
body fat changes from month one to month six postpartum. This result suggests
that those women who lost the most body fat during the study were the subjects who
were tending to eat more calories in month six compared to month one postpartum.
This is opposite to what would be the expected result. One would expect that a
subject consuming less calories throughout the study would lose more body fat. It is
also interesting to note that although a significant relationship was found between
the difference in calories and body fat, there was not a significant relationship
between the difference in calories consumed from month one to month six
postpartum and the weight change from month one to month six postpartum. It would be expected that, since the postpartum fat loss and weight loss are very strongly correlated, then they both should be correlated to the difference in calories consumed during the study. However, this was not the case and thus, this result further supports that fat loss during the postpartum period is a multi-factorial, complex phenomenon.

**Infant Size Measurements:**

Although the mothers in the present study were aggressively exercising and were not consuming any more calories as a result of their exercise sessions and, in fact, were consuming 200-350kcal less per day than the RDA of 2500kcal/day they still were developing babies with healthy height and weights. The average infant weight, height and head circumference at 6 months postpartum in the present study were 7.6+\-0.8kg, 68.4+\-2.0cm, and 44.3cm respectively and all measurements fall within or above the norms for infant growth reported by Hamill (1979). This suggests, indirectly, that the mothers' exercise sessions did not negatively affect her milk production and that the RDA of 2500kcal/day for lactating mothers may be too high. The present study expected to show a relationship between maternal fat loss and infant weight gain; however, no significant relationship was found.
RELIABILITY

Reliability can be influenced by many factors. But all variable instruments (calipers, DXA, weight scale) were calibrated and anatomical sites were consistently landmarked. Skinfold and girth measurements for any given site, in duplicate, were not taken in succession. The entire set of sites was assessed once and the process repeated again. This prevents tissue compression from affecting the results. Also 2 seconds passed before skinfold readings were taken to allow for readings to stabilize. If there were deviations above pre-determined values, a third measurement was taken.

The extent to which subjects complied with respect to a voided, post-absorptive state, drug-free state and a normal state of hydration could affect reliability, but any effect is likely of little magnitude.

The extent to which subjects completed maternal and infant food diaries and activity diaries accurately is also an issue. However, the subjects were instructed how to use these methods correctly.

The extent to which subjects adhered to the exercise and exclusive breastfeeding protocols could also be an issue; however, the maternal logs indicate strong adherence to the protocols.
VALIDITY

The use of skinfolds, the sum of girths and DXA regional fat measurements as a valid assessment of regional fat deposition is questionable.

The use of skinfolds require the following assumptions: a) constant compressibility of tissue b) negligible skin thickness or skin thickness to be a constant fraction of the skinfold and c) fixed proportion of internal to external fat. None of these assumptions are actually true (Martin et al, 1991). Skinfolds, however, are a valid method by which to assess adiposity so long as illusions about individual predictions of % fat are not entertained (Martin et al, 1991).

The validity of DXA in assessing body composition has yet to be established in humans by comparison with chemical analysis, however, Brunton (1993) found that body fat measured by DXA was 35% higher than the true value in large piglets.

In vitro studies have found DXA short and long term precision for body composition measurements to be very good ranging from .2-2%. In vivo studies have determined that fat estimation were also fairly precise, however, with larger errors ranging from 1.7-6.4%. The poorest reproducibility surfaced when attempting to assess regional fat distribution. Drinkwater et al (unpublished) reported a 17.1% precision for the upper limbs and a 1.3% precision for the lower limbs. Pritchard et al (1993) reported a coefficient of variation of 2.0% for trunk
fat% and a coefficient of variation of 3.6% for lower limb fat%. Snead et al (1993) reported that only 55% of the exogenous fat (lard placed over the body in different regions) was identified as fat when it was in the trunk region compared with 96% when it was positioned over the legs. DXA studies seem to suggest that we can be confident with DXA BMC, BMD, Total body fat, Fat % and regional fat reported in the thighs. However, we should be less confident with the DXA regional fat reported in the trunk and the least confident in the reported arm fat. The other major concern with DXA regional fat distribution is the values used to indicate fat regions. DXA categorizes trunk fat as the fat contained in the area extending from the cervical vertebrae down to the pubis bone, including the pelvis but not including the femur. Therefore, DXA trunk fat includes abdominal and gluteal fat. DXA categorizes abdominal fat as the fat contained in the region extending from the bottom of the pelvis up to the lower ribs. The DXA abdominal fat measurement would therefore also include gluteal fat. The DXA thigh fat measurement only includes fat contained in the legs since the measurement begins at the neck of the femur on a diagonal cut, therefore, this measurement does not include gluteal fat. Based on these DXA categories we cannot separate true abdominal fat from gluteo-femoral fat. The only true valid method of assessing maternal fat and regional fat
deposition is by extraction of the fat, and this is, obviously, not a possibility for this study.

OBJECTIVITY

Objectivity of testing procedures was a primary concern. For anthropometric measurements, inter-observer reliability is not an issue because the author performed all anthropometric measurements. Although, it is not possible to set up and conduct the anthropometric measurements blind (the author knew the study hypothesis and purpose), this is not viewed as a serious limitation or threat to objectivity. Intentional bias was resisted and, although unconscious bias cannot be ruled out, any effect was likely to be of little magnitude.

LIMITATIONS

The sample group was composed of 11 breastfeeding, exercising subjects from a wealthy, upper-income area. Due to a small subject sample and a specialized sample pool, it is difficult to draw any concrete conclusions and generalize the results. In addition, the lack of a control group for the present study makes it difficult to interpret the results.

SIGNIFICANCE

To our knowledge, no other study has examined this population using DXA and since it appears that DXA may become the gold standard for body composition
measurement, it will allow for comparisons for future studies. The present study has also offered the most comprehensive body composition analysis, specifically, regional body fatness examining 4 skinfold measurements, 8 girth measurements, DXA BMC, BMD, LTM, total body fat, body fat %, DXA regional body fatness and weight.

It’s also important that health professionals notice the difficulty that the present study’s subjects had returning to their pre-pregnancy weight. They should be more sympathetic to the struggle and suggest to women that they can expect to return to their pre-pregnancy weights and figures within the range of 9-12 months postpartum.

The author would also like to emphasise her belief that weight and fat loss during the postpartum period appear to be multi-factorial similar to weight and fat loss during any other period in a woman’s life and that it will be an individual experience based on genetics, maternal activity levels, maternal metabolic rate, maternal caloric intake, infant size, and infant feeding patterns.

SUGGESTIONS FOR FUTURE STUDIES

It is difficult to determine whether any of the reported changes during lactation are long-lasting because the majority of studies occur over a six month period or less. A longer study would indicate more enduring results.
In addition, because there are so many factors affecting weight and fat loss during the postpartum period, any future attempts should control for all the confounding variables in order to provide for more accurate generalizations.

A study that compared breastfeeding/exercising, breastfeeding/non-exercising, non-breastfeeding/non-exercising and non-breastfeeding/exercising, used a large sample pool, controlled for all dependant variables, studied the onset of the menstrual cycle and hormonal changes, used the present study’s measurement tools for body composition analysis and included underwater weighing in the testing procedures and tested the subjects monthly from month one to month twelve postpartum would be an ambitious but well-received study.

It is also suggested more well-designed studies be performed in the area of body composition research since the entire science appears to hold large sources of error. It would be helpful if a gold standard for body composition measurement could be agreed upon by the experts in this area so that standards could be reassessed and universal measurement tools could be used.

Finally, the values used to indicate DXA regional fat distribution should be reassessed since they actually do not indicate the actual fat in the described regions.
SUMMARY

The present study shows that maternal body composition and aerobic capacity was improved in 11 breastfeeding, exercising subjects. We did not demonstrate that breastfeeding, exercising women lose more body fat from their gluteo-femoral region compared to their abdominal region and we did not show that exercising, breastfeeding women return to their pre-pregnancy weights by six months postpartum as expected. Although these data indicate that breastfeeding and exercise will not necessarily return a mother more quickly to her pre-pregnancy figure or eliminate the weight gain associated with childrearing, the results still provide further support for the overall positive effects of exclusive breastfeeding and exercise for both the infant and the mother.
REFERENCES


Changes in maternal body composition from month one to month six postpartum in breastfeeding, exercising women

Researcher: Sherri Kwasnicki, B.H.K., Graduate Student  
Supervisor: A.D. Martin, Ph.D., University of British Columbia

Background:

Breastfeeding has been found to be more beneficial to the health of the child when compared to formula feeding. Evidence suggests that breastfeeding protects the infant against gastrointestinal disorders, respiratory illness, otitis media and promotes growth and psychological development in infants. As a result, many organizations are taking an aggressive approach to the promotion of breastfeeding.

In recent years, information has surfaced to suggest that breastfeeding also provides the mother with benefits. Most women will attest to the fact that women tend to distribute fat in the lower body. Research now provides us with the reason for this dilemma. The enzymes responsible for storing fat in the lower body are very active in women. This promotes fat storage in the lower body. Furthermore, the enzymes responsible for breaking down fat in the lower body are very inactive. This promotes maintenance of existing lower body fat. However, during lactation this pattern of fat storage in women is reversed. The enzymes responsible for storing fat become very inactive and the enzymes responsible for breaking down fat become very active in the lower body. This promotes the reduction of lower body fat. However, these results have been confirmed in animal research only. Human research has shown contradicting results. Furthermore, no studies have been performed in humans to examine the effects of exercise on maternal body fat in breastfeeding women.
The Fitness Group, 3507 West 4th Ave., is offering all subjects a 6 month gym membership at half price for $141. They offer a program on Mondays, Wednesdays and Fridays from 11:00-12:00 where you can actually bring your baby into the gym and exercise with them right beside you. This may help you adhere to the exercise protocol. We encourage you to become involved with this program also for the social aspects.

Commitment: To obtain the information needed to conduct this study, the following measurements will be made on all participants. The measurements will take place approximately one month post-pregnancy and then again, six months post-pregnancy. A total time commitment of approximately two hours is required on each occasion to take the measurements. Additionally, participants are required to complete activity and food diaries throughout the study. Therefore, a participant participating in the study will be required to commit to a total of 8 hours over the 6 month study (2 hours x 2 for laboratory measurement and 4 hours for completion of maternal and infant food and activity diaries). Additionally, all subjects will be required to exercise 4 times a week for a total duration of 40 minutes of cardiovascular activity (walking, biking, running, stairmaster) each session.

Anthropometry: Anthropometric measurements, including height, weight, several skinfold and girth measurements will be made at St. Paul’s Hospital. This entire procedure will take about one hour. These measurements will allow for the estimation of the volumes of adipose tissue, muscle and bone in your body. Measurements will be made in duplicate and sum of skinfolds will be used as an index of fatness. You should wear short tights or loose fitting running shorts and a t-shirt and bra-top. You should not eat 3 hours before testing but must have eaten within 12 hours of testing. You should attempt to urinate and defecate before arriving. Salty food, exercise under hot, humid conditions, sauna bathing or any extremes of over or under-hydration must be avoided (hydration change equivalent to body weight change of 1-2kg).

Bone Density Measurements: Bone density determination will also be made at St. Paul’s Hospital, preferably on the same day as the anthropometry measurements. This procedure requires that you be exposed to a small amount of radiation (less than a chest x-ray). Measurement will involve a scan of your total body from head to toe. These bone density measurements will allow estimation of the bone mineral content of your body. Additionally, an estimation of percent body fat can be
obtained. For the total body scan you will be asked to lay on your back for about 20 minutes. Wear loose fitting, comfortable clothing without metal buttons or zippers.

**Aerobic Capacity:** A submaximal walking treadmill test will be completed at The Fitness Group, 3507 West 4th Ave, preferably in the same week as the other measurements. The test will take approximately 15-30 minutes. You should not eat 2 hours before testing but must have eaten within 12 hours of testing. You should not have exercised immediately prior to this test. You should not have consumed alcohol, drugs, caffeine or nicotine within 24 hours of this test.

In addition to these two appointments, each subject will be required to complete a 3day/24hour maternal food recall diary, and a 3day/24hour infant feeding pattern diary at one month postpartum, 4 months postpartum (only maternal food diary) and 6 months postpartum. Each subject will also be required to complete an activity log throughout the entire study. Sheets will be provided and it will be required that subjects complete the forms accurately. Each maternal and infant food diary will track two weekdays and one weekend. This will require an approximate total time commitment of 4 hours.

**Risks and Discomforts:**

Assessment of skinfold thickness by application of skinfold caliper may cause mild discomfort.

Anthropometrical measurements in general may cause psychological discomfort in that minimal clothing must be worn during these procedures.

You will be exposed to a small amount of radiation during the assessment of bone mineral density. The dosage you will receive is about 5% that of a standard chest X-ray—about the same amount of radiation you might be exposed to if you flew from Vancouver to Toronto.

For all procedures, trained personnel will conduct the testing, and emergency procedures have been outlined to deal with any unusual situations that may arise.

**Data Collection:**

You are assured that data collected by this investigation will remain confidential with regard to your identity. All participants in this study will be identified only by
APPENDIX B

Subject Screening Questionnaire

University of British Columbia
Human Kinetics Research

Changes in maternal body composition from month one to month six postpartum in breastfeeding, exercising women

This questionnaire is concerned with determining your eligibility for participation in this study. It is important that you consider each question carefully and answer truthfully. The first section concerns descriptive personal information which must be obtained so that you can be contacted. The second section concerns medical information regarding your current state of health. The third section is concerned with eliciting information directly relevant to your status within this study.

Section I: Personal Information

Full name: _____________________________________________
(Surname) (Given) (Middle)

Date of Birth: ___________________________ Age: ______
(Day) (Month) (Year)

Address: _____________________________________________
(Street Number) (Street)

(City) (Postal Code)

Telephone Number: _______________________________________
(Home) (Business)
Section II: Health Status

1) Has a doctor ever said you have heart trouble? Y/N

2) Do you frequently have pain in your heart and chest? Y/N

3) Do you often feel faint or severely dizzy? Y/N

4) Has a doctor ever said your blood pressure was too high? Y/N

5) Are you currently pregnant? Y/N

If you answered yes to this question, then please indicate:
   a) Expected birth date: ________________________
      (Month) (Day) (Year)

   b) Pre-pregnancy weight: ______________ lbs

   c) Have you experienced any medical or obstetrical problems? Y/N

      If you answered ‘yes’ to this question, please indicate the nature of your problems:
      _________________________________________________________________
      _________________________________________________________________
      _________________________________________________________________

6) Have you recently had a baby? Y/N

If you answered yes to this question, then please indicate:
   a) Infant Birth Date: ________________________
      (Month) (Day) (Year)

   b) Your postpartum age (in days): _______________ days

   c) Pre-pregnancy weight: _______________ lbs

   d) Total pregnancy weight gain: _______________ lbs
e) Have you experienced any medical or obstetrical problems? Y/N

If you answered 'yes' to this question, please indicate the nature of your problems:

_________________________________________________________________________

_________________________________________________________________________

7) Do you or are you taking any prescription or non-prescription drugs on a regular basis? Y/N

If you answered 'yes' to this question, then please indicate:

a) the name of the drug(s):

_________________________________________________________________________

b) what you take it for:

_________________________________________________________________________

8) How many babies have you previously given birth to? __________

Section III: Study Status

Part A: Infant feeding Status

8) Do you plan on breastfeeding or formula feeding your infant? __________

Breastfeed / Formula Feed
(Please circle)

9) Have you ever breastfed with previous children? Y/N/1st child

10) Why have you chosen your particular method of infant feeding? __________

_________________________________________________________________________

_________________________________________________________________________

11) If you have chosen to breastfeed, what circumstances would cause you to discontinue:

_________________________________________________________________________

_________________________________________________________________________
Part B: Status of Physical Activity

12) Were you physically active before your pregnancy? Y/N

If you answered ‘yes’ to this question, then please continue with the following questions.

If you answered ‘no’ to this question, then please go to question (19).

13) You were physically active before your pregnancy. Please indicate the types of activities you participated in:

__________________________________________________________

14) Please indicate the number of hours that you trained or were physically active per week: _________________ hours/week

15) Please estimate the average intensity of your training:

low low/moderate moderate moderate/high high
(Please circle a category)

16) Are you a competitive athlete? Y/N

If you answered ‘yes’ to this question, then please

a) indicate the level of competition (e.g. amateur, professional): ____________________________

b) describe the nature of the competition: _______________________________________________

17) Did you continue exercising throughout your pregnancy? Y/N

If you answered ‘yes’ to this question, these please indicate:
a) how your training changed during your pregnancy (i.e. intensity, duration, frequency, types of activities) ____________________________________________________________

__________________________________________________________
18) Do you plan to continue with your present level of training over the next 6 months? Y/N

19) You were not active before or during your pregnancy. Do you plan on participating in structured exercise over the next 6 months? Y/N

RESEARCHER’S NOTES:__________________________________________

Part C: Smoking Status

20) Please indicate your smoking status: Smoker / Non-smoker (Please Circle)

Thank-you for completing this questionnaire. You are assured that this information will remain strictly confidential. You will be notified in the near future as to whether or not you are a suitable subject for this study.