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Bone mineral density (BMD) decreases during lactation, therefore, the purpose of this study was to examine if exercise could slow this loss. Women were randomized to either an exercise group (EG, n=5) [aerobic (3d/wk, 45 min/d) and resistance exercise (3d/wk)] or control group (CG, n=6) (no exercise) during the 16 wk study. Body composition and BMD were measured by dual x-ray absorptiometry at lumbar spine (LS), hip, and total body.

Significant differences in change from baseline between CG and EG were observed for LS bone mineral content (BMC) (-7.4 ± 2.4 vs. $-2.9 \pm 1.0\%$, $p<0.01$) and LS BMD (-6.9 ± 1.9 vs. $-4.6 \pm 1.1\%$, $p=0.03$), respectively. LS area increased by $1.8 \pm 1.2\%$ in the EG vs. a decrease of $-0.6 \pm 2.7\%$ in the CG ($p=0.09$). No significant differences in percent change were seen in total body BMD and total hip BMD. EG women lost more fat mass (-2.1 ± 2.9 vs. -1.5 ± 1.7 kg) and less lean body mass (-1.0 ± 1.2 vs. -1.9 ± 0.8 kg), however these changes were not significant.

These results suggest that resistance and aerobic exercise slow BMC loss and increase bone area of the LS resulting in less loss of BMD during lactation.

EFFECT OF EXERCISE ON BONE DENSITY

AND BODY COMPOSITION DURING

LACTATION

by

Heather Lynne Kennedy

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APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

Osteoporosis is commonly referred to as the "silent disease" because bone loss occurs without symptoms (1). According to the National Osteoporosis Foundation, "osteoporosis, or porous bone, is a disease characterized by low bone mass and structural deterioration of bone tissue, leading to bone fragility and an increased susceptibility to fractures, especially of the hip, spine and wrist, although any bone can be affected." A hip fracture can impair a person's ability to walk unassisted and may cause prolonged or permanent disability or even death (1). Spinal or vertebral fractures also have serious consequences, including loss of height, severe back pain, and deformity (1). The National Osteoporosis Foundation estimated that the national direct expenditures of hospitals and nursing homes for osteoporotic and associated fractures to be $18 billion in 2002 and the costs continue to rise (1).

Osteoporosis is typically found in older women, especially after menopause. However, it can also be found in men and rare cases have been seen in younger individuals. This disease affects an estimated forty-four million Americans, or fifty-five percent of the people fifty years of age or older. In the United States today, ten million individuals are estimated to already have the disease and almost thirty-four million are estimated to have low bone mass, placing them at increased risk for osteoporosis (1).

Achieving peak bone mass is important to bone health. One achieves peak bone mass by the time they are thirty (1). Achieving and preserving peak bone mass is imperative and can be obtained by a balanced diet rich in calcium and vitamin D, weight-bearing exercise, a healthy lifestyle with no smoking or excessive alcohol intake, talking to one's healthcare professional about bone health, and bone density testing and medication when appropriate (1). In women, most bone is lost in two stages of life. The rate of bone loss increases after menopause, when the ovaries stop producing estrogen, the hormone that protects against bone loss (1). However, it has been shown that hormone replacement therapy (HRT) can improve bone status, but not without consequence. HRT can increase the risk for heart disease, breast cancer, and stroke. Bone loss also occurs when women breastfeed their babies. Several studies have shown that women lose three to nine percent of their bone density at trabecular rich sites during lactation (2-6). However, it has been shown that most women who lose bone during lactation regain that bone loss after weaning, making breastfeeding a safe feeding choice for their child and themselves (5,7,8).

Bone mass can also be improved or maintained by resistance exercise, such as weight training (9). Aerobic exercise also increases bone mass by using body weight as the resistance. Walking and running are great ways to increase or maintain bone mass while increasing cardiovascular fitness (10).

Statement of the Problem

Lactation is associated with bone loss at the lumbar spine, the hip, and total body. This loss is unaffected by calcium supplementation and could possibly increase the risk of osteoporosis later in life.

Purpose of this Study

Currently, there is no research on whether exercise can slow the rate of loss of bone during lactation; therefore, the purpose of this research project is to assess the effects of exercise on bone mineral density (BMD) and body composition during lactation from four weeks postpartum to twenty-one weeks postpartum. We hope to slow this loss by resistance and aerobic exercise. It is known that this bone loss typically returns to baseline levels after the child is weaned or after menses return. We hope that slowing bone loss during lactation will help enhance the amount of bone to a level at or above baseline values post-weaning.

Hypotheses

The author proposed the following hypotheses for the study:

1. There will be no significant difference between exercise and control groups in BMD at the baseline time point. At twenty-one weeks postpartum, the exercising women will have experienced less total BMD loss than sedentary women as a result of the exercise intervention.
2. There will be no significant difference between exercise and control groups in fat and lean body mass at the baseline time point. At twenty-one weeks postpartum, the exercising women will have experienced greater weight loss than sedentary

women as a result of the exercise intervention due to a reduction in fat mass. At twenty-one weeks postpartum, the exercising women will have also experienced greater gains in lean body mass than their sedentary counterparts.

3. Women in the exercise group will have improvements in both cardiovascular fitness and muscular strength as a result of the exercise intervention. Measures should remain unchanged in the sedentary group.

Limitations

Due to time and funding constraints, this study does have limitations. The ideal situation would be to follow these women through the entire lactation period, allowing them to breastfeed as long as they desire. Documentation of the effects of exercise-training program both acutely and chronically would provide valuable information. It would also be helpful to follow these women until six months or one year post-weaning to determine if any or all possible bone losses are recovered, or if perhaps, some of the women have higher BMD as compared to baseline. Since some mothers choose to nurse for twelve, eighteen, or twenty-four, or more months, it is simply not feasible to follow these women that long for this project. Another limitation of this study is simply the sample size. At this writing 11 women have completed the study, ranging in age from 23-37 years of age, and a body mass index from 20-30 kg/m^2. In order to have included a larger number of subjects it would have involved having more help to work with the mothers during the workouts and it also would have required more financial support. Another issue that would have made recruiting much easier would be to accept women of any age or weight in order to increase our sample size.

Other limitations include compliance issues and the feasibility of this type of exercise intervention being applicable to the everyday population. We had a reasonable compliance rate (aerobic: 88.7%, resistance: 98.2%), however, these mothers had someone coming to their house at a scheduled time three times per week while to act as a personal trainer and childcare provider and they exercised on their own three times per week to total six days per week total. Not having this benefit of the study makes it more difficult for the mother to continue with this type of exercise without outside support. One way we attempted to increase compliance was to check the heart rate monitors worn by the exercising women at each visit to document the recorded exercise from any previous unsupervised aerobic session. Research assistants were also in the subject's home three days per week, during their exercise session to improve compliance. Another problem might be if women in the sedentary group began exercising even though they agreed to continue their normal sedentary routine. Compliance was assessed by measuring changes in strength and cardiorespiratory fitness levels.

A potential problem includes possible human error via the x-ray technician, in both placement of the subject on the scanning table and reading of the x-ray output. In most instances, the same trained technician scanned all subjects and analyzed all output to ensure optimal reliability, precision, and accuracy of the results. Another anticipated problem was human error during the measurement of strength and cardiovascular fitness. However, the same research assistant performed all measurements to ensure optimal, reliability, precision, and accuracy. It also would have been of benefit to have seen a bone scan that shows bone shape and size in order to better determine changes in bone as a result of exercise and lactation and risk for osteoporotic fractures.

Conclusion

The remainder of this thesis contains a literature review, a description of the study that was conducted, the results and discussion of the study, and conclusions made based on those results.

CHAPTER II

REVIEW OF THE LITERATURE

Bone Mineral Density Changes During Pregnancy and Lactation

Drinkwater and Chesnut reported that nine months of pregnancy caused a significant decrease in bone mineral density (BMD) of the femoral neck and radial shaft and an increase of the tibia (2). Decreases in bone density occur in areas high in trabecular bone, such as the lumbar spine and the pelvis, while areas high in cortical bone, such as long bones of the arms and legs, often increase. Trabecular bone can provide the amount of calcium newborns require due to fast resorption capabilities. Even though most women experience a decrease in bone density, it is often redistributed to areas such as the tibia and forearm (3). Cases of pain in the hip have been reported, especially during the third trimester of pregnancy (2). It has been suggested that women who have successive pregnancies might actually decrease their risk of hip and possibly vertebral fractures. Each pregnancy can decrease the risk by up to nine percent. One possible explanation is that with each pregnancy there is improvement in the biomechanical resistance of the upper femur. It is thought that there is expansion of the outer diameter of the femur, increased cortical bone thickness, or changes in the pelvic geometry (3). However, all bone losses that occur during pregnancy return to baseline levels without lactation.

Paton *et al.* (11) conducted an epidemiological study examining the long-term effects of pregnancy and lactation on measures of bone mineral in healthy women. They analyzed three data sets: 1) 83 female twin pairs (21 monozygous and 62 dizygous) aged 42.2 ± 15.5 years who were incongruous for ever having been pregnant for greater than twenty weeks; 2) 498 twin pairs ages 42.3 ± 15.0 years; and 3) 1354 individual twins, their siblings, and family members. This study was based on one time point and primarily used pre-menopausal women. They found no long-term detrimental effect of pregnancy or lactation on bone mineral mass when comparing twin pairs, sister pairs, and other female relatives (11). There was no detectable long-term effect of either pregnancy or lactation on regional areal BMD or total-body BMC in eighty-three female twin pairs incongruent for ever being pregnant. A larger sample size of four hundred and ninety-eight female twin pairs had no within-pair differences in bone mass, either unadjusted or adjusted for age, height, and fat mass. Total-body BMC was significantly higher in women who had three or more pregnancies compared to their twin who had less than three pregnancies. However, after adjusting for age, height, and fat mass, there was no significant difference in total-body BMC. The final part of this investigation included 1354 individual females including members of twin pairs, sister pairs, and their female relatives. These women were divided into three groups: 1) no pregnancies more than twenty weeks, 2) one or two pregnancies beyond twenty weeks, and 3) those with three or more pregnancies beyond twenty weeks. In this group of women, when examined cross-sectionally, after adjustment for age, lean mass, and fat mass, total-hip BMD and lumbar spine BMD were greater in the women who were in the groups of one or two pregnancies or three or more pregnancies than those who had no pregnancies. This indicates that pregnancy may have a positive effect on bone density independent of body composition (11).

Several studies have shown that women lose three to nine percent of their bone density at trabecular rich sites during lactation (2-6). Bone is in a state of high turnover during the first three months of lactation (3). This increase in turnover is due to a greater increase in bone resorption compared to bone formation (12). Laskey *et al.* (13) reported that at three months of lactation, bone mineral content (BMC) decreased significantly at the lumbar spine, femoral neck, total hip, thoracic spine, pelvis, and whole body. At the spine, the change in BMC was negatively correlated with maternal height and breast-milk volume. This means that the percentage decrease in BMC would be greater for taller women and those producing larger volumes of breast milk. Lighter women and those with a smaller bone area (BA) had a greater percentage decrease in BMC at the femoral neck (13). After breast-feeding for six months, women experience a significant decrease of approximately five percent in the BMD of the lumbar spine (14-19). After almost twelve months of breast-feeding, a decrease in density of the spine continued, with some women losing up to ten percent (20).

Although bone density is decreased during lactation it appears to increase after weaning or the resumption of menses in women who are still breast-feeding. Often, bone density returns to baseline values within twelve to eighteen months postpartum (7). Laskey and Prentice (8) reported that length of time needed for complete recovery of bone is dependent upon length of lactation, the length of postpartum amenorrhea and the skeletal site being examined. Length of postpartum amenorrhea was also a better predictor of bone density changes than length of lactation (8). Kalkwarf and Specker concluded that during the first six months postpartum, there was a greater decrease in total body BMC and lumbar spine BMD in women who had not resumed menses compared with those who had resumed, even after correcting for weight loss (5). This could possibly be because women may not be at full lactation if they had resumed menses as compared to those who had not resumed menses and are exclusively breastfeeding. Lactation is associated with prolonged postpartum suppression of the hypothalamic-pituitary-ovarian axis and amenorrhea is the result. The deleterious effects of amenorrhea on bone have been well established. Kalkwarf and Specker also demonstrated that after weaning, lactating women tend to gain more BMD than non-lactating women, 5.5 vs. 1.8 percent, respectively, in the lumbar spine. This gain of BMD has been shown to continue up to six months after weaning, often to pre-pregnancy levels or higher. This regain of BMD is why lactation is thought to be safe and not increase the risk of osteoporotic fractures (5).

Even though most women return to baseline BMD values, there are small groups of women that do not return to baseline levels and this increases the risk for osteoporotic fractures. Women at the end of their childbearing years may experience declining ovarian function and may not be able to recover bone density before menopause occurs and this is of great concern as well (4). One reason explaining this phenomenon is that age is positively related to increased bone turnover during postpartum amenorrhea as reported by Holmberg-Marttila *et al.* (21).

Paton *et al*. (11) also examined breastfeeding and bone mineral density in twins and other female relatives and found that cross-sectionally, when parous women who had breastfed were compared to those women who had not breastfed, those who had breastfed had a greater adjusted total-body BMC and a lower fat mass. Ultimately, Paton et al. (11) concluded that pregnancy and lactation appear to have little residual effect on the skeleton.

Calcium Requirements

Calcium demands are elevated by about 200-300 mg/d during pregnancy and lactation with some demands being as high as 450 mg/d (2,4,6,13). This demand could be satisfied by an increase in dietary calcium, an increase in intestinal calcium absorption, a decrease in calcium excretion, or by mobilization of maternal bone mineral (6). The adequate intake (AI) of calcium for pregnancy and lactation is 1000 mg/d (21). Bone is a major storage site of calcium in the body, and some of the calcium in bone is mobilized to provide calcium needed for milk production (4). The homeostatic mechanisms that occur to provide maternal calcium differ during pregnancy, lactation, and after the resumption of menses. Ritchie *et al.* (6) reported that calcium absorption is elevated during pregnancy to provide fetal bone mineralization. It is also elevated after weaning, but not during lactation. There appears to be no net loss in maternal bone mineral due to this increase in calcium absorption during pregnancy and weaning. There is an increase in urinary calcium excretion during pregnancy and a decline during lactation and after the resumption of menses. By the second trimester fasting serum calcium had decreased slightly but significantly, and then returned to pre-pregnancy concentration postpartum (12). Renal calcium conservation occurs during early lactation, along with spinal bone mineral resorption. After the resumption of menses, renal calcium conservation continues and spinal bone mineral is recovered (6).

The needed calcium for fetal bone mineralization does not appear to negatively affect maternal bone among well-nourished adult women (6). Allen concluded that breast milk calcium appears to be obtained primarily from maternal spinal trabecular bone, with the reduction in urinary calcium contributing to calcium retention. It was thought that calcium supplementation during lactation could reduce the bone density changes seen in pregnancy; however, this does not seem to be the case. Calcium mobilization to the fetus and to breast milk is due to changes in maternal metabolism and is not influenced by the amount of dietary calcium consumed, unless intake is less than 800 mg/d (22). Women who consumed calcium in excess of the AI of 1200 mg/d throughout pregnancy and lactation still experienced significant bone loss at two skeletal sites during pregnancy and a continued loss at the femoral neck during lactation (2). Calcium supplementation only has somewhat of a protective effect when calcium intake is below approximately 800 mg/d (3).

However, it has been suggested by some that there might exist a small population of women who may be at an increased risk for bone loss during lactation and may benefit from supplementation or increased calcium intake when compared to most women (23). This increased risk group includes women who are nursing more than one child, women with closely spaced pregnancies, and lactating adolescents (24). However, Bezerra et al. (25) has suggested that it appears that adolescent mothers with a habitually low calcium intake still recover from the lactation-associated bone loss in the postweaning period, after the resumption of menses. Still, the rate of bone accumulation may not be sufficient to ensure full bone restoration at levels similar to those in adolescents who were never pregnant (25).

Exercise and Lactation-Safety Issues

Moderate exercise with weight loss of no more than two kilograms per month has been shown to be beneficial to the mother (i.e. weight loss, fat mass loss, and improved cardiovascular function) and not detrimental to the infant in terms of milk production (i.e. volume, energy output, and composition) during lactation (26). Dewey *et al*. (27) has shown that aerobic exercise that is frequent and moderate has been shown to be safe for breast-feeding mothers, even those that were sedentary prior to pregnancy. No significant differences in changes of breast milk intake by infants, energy output in milk, or the infants' body weight have been shown between exercising women and non-exercising women (27). The breast milk composition (lipid, lactose, protein concentrations, and energy density) and plasma hormones (i.e. prolactin, cortisol, insulin, and T_3) do not differ between exercising women and non-exercising women (27-29). However, Dewey *et al*. (27) reported that protein concentration of breast milk has been shown to be slightly higher in the exercising women, however, not significantly different from the control women.

Dewey *et al.* (27) has also shown that mothers who exercise do not experience any difficulties nursing after exercise. McCrory has shown that feeding frequency and total time spent breastfeeding is also not altered when women decide to exercise (28).

Although increased exercise results in higher energy needs, hormone changes may promote greater efficiency in milk synthesis, which protects milk production even though a high energy expenditure exists (29). Regular exercise also increases the sensitivity of adipose tissue and muscle cells to insulin and enhances fatty-acid use during peak exertion. These may facilitate blood glucose homeostasis and the mobilization of fat stores during lactation (27,30). These results show that exercise during lactation has the ability to improve cardiovascular fitness and may affect some parameters of maternal metabolism (30). Bopp *et al.* (31) has reported that women consuming adequate amounts of long-chain polyunsaturated fatty acids can exercise moderately without decreasing the long-chain polyunsaturated fatty acids in their breast milk. Lovelady *et al.* (32) has also reported that moderate weight loss of approximately 0.5 kg/wk in overweight, lactating women did not affect vitamin B6 status or infant growth. This is very important because a low B6 status of the mother results in low concentrations in the breast milk, which could adversely affect the growth and/or behavioral development of the infant (32). Lovelady *et al.* (33) also demonstrated that moderate exercise during lactation not only improves cardiovascular fitness, but also, does not affect levels of immunoglobulin A, lactoferrin, or lysozyme in breast milk. Although not studied, historically physicians recommended that mothers discard their breast milk produced after exercise, but these findings change the current recommendations. These findings suggest that there is no need to discard breast milk produced within the first hour after moderate exercise (33).

Exercise and Bone Mineral Density Changes

Regular exercise effects bone density, size, and shape, resulting in improvements in mechanical strength. Proper exercise can add new bone and/or reduce bone loss ultimately to affect bone mass, but bone mass is not an accurate measure for bone strength. For a true assessment of the effectiveness of exercise on bone strength, bone size and shape should be measured (34). Exercise also enhances skeletal mineralization due to the mechanical forces exerted by gravity and muscle contraction (35).

It is thought that there is a bone remodeling set point, the point at which bone begins to remodel or form. Mechanical stresses, such as weight-bearing exercise, will decrease this set point, meaning that it is easier for bone to form. However, during pregnancy and lactation estrogen is deficient, and this will increase the remodeling set point, meaning that it is more difficult for bone to form. Therefore, a greater mechanical stress, or more intense exercise, is necessary to maintain or improve bone mass during lactation (35).

The required mechanical load needed to initiate new bone formation decreases as the loading frequency increases, indicating that it is important to develop a high-frequency loading program that will improve cortical bone mass and bone strength. Periods of rest are also important between short vigorous skeletal-loading sessions. It is best to add more exercise sessions per week than increasing the duration of individual sessions. Short, intense exercise bouts build bone most effectively (34).

Cussler *et al.* (9) reported that increases in BMD at the femoral neck and at the lumbar spine have been associated with weight-training exercise in post-menopausal women. The greatest changes in BMD after weight-lifting for one year were found in the femur trochanter. The smallest effects were seen at the lumbar spine and total body. Exercises that resulted in statistically significant linear relationships between weight lifted and increased femur trochanter BMD included squats, military press, lat pull, seated row, rotary torso, seated leg press, and the weighted march. The weighted march also increased total body BMD. Higher intensity (i.e. higher weights and/or higher repetitions) showed a greater increase in lumbar spine BMD than lower intensity; however, the difference was not significant. This could be due to several reasons, including: muscle attachment, hormonal factors, differential loading or type of strain, and the nature and duration of the exercise intervention. Ultimately, the more weight lifted in one year, the greater the increase in BMD (9).

A well-balanced strength training program will provide the best approach to an osteoporosis prevention program (9). It is also important to realize that exercise can effectively reduce osteoporotic fracture risk even without dramatic effects on bone mass. The key to reducing fractures is to reduce the frequency of falls. Proper exercise can reduce falls by improving balance and postural stability, even if bone strength itself is not improved significantly (34).

It has been shown that exercise provides a greater stimulus to bone than calcium alone, but adequate calcium intake is necessary to provide the exercise-induced gains in bone mass (10). It has been suggested that adults that engage in weight-bearing exercise, at intensities greater than sixty percent of aerobic capacity, consistently have a greater BMD than their non-exerciser counterparts or those exercising at a lower intensity.

Walking, by itself, is not enough to benefit by the gains seen in weight-bearing resistance exercise. Resistance training must be accompanied to see the true benefit of exercise on BMD (10). In general, weight-bearing exercise must overload the skeleton to see benefits. A magnitude of forces greater than two-and-one-half times body weight at the hip and spine should be strived for in order to provide osteogenic effects (10).

Vainionpää *et al.* (36) conducted a study of eighty, healthy, premenopausal Finnish women aged thirty-five to forty that were randomized to a twelve month high-impact exercise intervention or a control group. They reported that twelve months of exercise led to significantly increased bone mass at the loaded bone sites in the lower extremities, but not at the non-weight-bearing bone sites. The exercise group showed a significant gain at the femoral neck BMD, intertrochanteric BMD, and total femoral BMD than the control group. The lumbar vertebrae one (L1) region BMD also increased more in the exercise group than in the control group. This study demonstrated that one to two hours of high-impact exercise plus two home-based exercise sessions for ten minutes each day is enough to ensure benefits to BMD (36).

Kemmler *et al.* (37) has shown how a mixed-intensity exercise program for three years can effectively compensate for most negative changes related to menopause. The overall trend in the spine, neck, and trochanter was stabilization of BMD in the exercise group and a decrease in the control group. However, in both groups total body BMD decreased significantly. There was, however, a continuous increase in the lumbar spine area after three years in the exercise group, which was caused by an increase of projected vertebral width rather than height (37). This increase in width could increase bone strength even if BMD were to stay constant (37). Another study by Maddalozzo and Snow suggests that high intensity free weight training can produce BMD changes in only six months in older adults (38). Both men and women in the high intensity exercise groups demonstrated a significant increase in BMD at the trochanter and a decrease at the femoral neck when compared to no training. For women, no significant difference in BMD between intensity groups (high intensity vs. moderate intensity) was observed at any bone site. However, percent changes in the high intensity group were two percent at the trochanter, but the large standard deviations and lower subject numbers (men: n=28, women: n=26) may not have provided enough sufficient statistical power to observe true significance (38).

Kohrt *et al.* (39) conducted an eleven month exercise and estrogen study in older women, beginning with two months of low-intensity exercise followed by nine months of more vigorous weight-bearing exercise for about forty-five minutes per day for three or more days per week at sixty-five to eighty-five percent of maximal heart rate. Thirty-two healthy women, aged sixty to seventy-two years old were randomized into either a control, exercise only, or exercise plus hormone replacement therapy (HRT) group. The exercise only group experienced significant increases in BMD at the lumbar spine, femoral neck, trochanter, and Ward's triangle when compared to the control subjects. They also reported that weight bearing exercise and HRT have independent, additive effects on BMD of the lumbar spine and Ward's triangle and a synergistic effect on total body BMD (39).

Exercise and Body Composition Changes – Fat and Lean Body Mass

Lovelady *et al*. (26) conducted a study of exercise and body composition changes during lactation and reported that a weight loss of 0.5 kilogram per week between four and fourteen weeks postpartum in overweight women who were exclusively breastfeeding did not affect the growth of their infants. Subjects were randomized to either a diet-and-exercise group (restrict energy intake by 500 kcal per day and to exercise 45 minutes per day for 4 days per week) or to a usual care group (to maintain their usual dietary intake and not exercise more than once per week). During this ten week study, the diet-and-exercise group lost between 1.7 and 8.3 kilogram, while the control group's weight varied from gaining 4.6 kilograms to losing 4.6 kilograms and this was statistically significant between the two groups. Weight loss was mainly due to a loss of fat mass (26). Dewey *et al.* (27) conducted a study on the effect of aerobic exercise on lactating women. Women were randomly assigned to either an exercise group (supervised aerobic exercise at 60-70% of heart-rate reserve for 45 minutes per day, 5 days per week, for 12 weeks) or a control group. They reported that aerobic exercise performed four or five times per week beginning six to eight weeks postpartum had no adverse effect on lactation and significantly improved the cardiovascular fitness of the women. However, the average weight loss was only 1.6 kg in both groups (27).

McCrory *et al*. (28) examined whether weight loss by dieting, with or without aerobic exercise would adversely affect lactation performance. Exclusively breastfeeding women were randomly assigned to a diet group (35% energy deficit), a diet plus exercise group (35% net energy deficit), or a control group for eleven days. They reported that a short-term weight loss (~ 1 kg/wk) through a combination of dieting and aerobic exercise appears to be safe during lactation and is preferable to weight loss achieved primarily by dieting. Dieting reduced maternal lean body mass, whereas dieting with exercise resulted in loss of fat mass only (28).

Since there are only three reports during lactation, other studies of non-pregnant, non-lactating women and pre- and post-menopausal women will be reviewed. Cullinen and Caldwell reported that muscular strength and fat free mass was increased in young women participating in a moderate-intensity twelve week weight training program (40). The increase in fat free mass was also joined by a decrease in body fat without restricting energy intake. Chilibeck *et al.* (41) found that a strength training program that effectively increased strength and lean tissue mass in young women failed to increase BMC and BMD, contrary to what would be expected from cross-sectional comparisons of weight training athletes to other groups and studies suggesting significant correlations between muscle mass and BMD-BMC (41). There was also a significant decrease in percent body fat in the exercising women. A twenty week strength training program was used because in the first few weeks of a strength training program, the increases in strength that are often observed are due to neural adaptations such as learning and coordination (41). Kohrt *et al*. (39) also found a significant reduction in body weight and body fat observed in response to exercise training that included walking, jogging, and/or stair climbing in post-menopausal women (39).

Kemmler *et al.* (37) found a non-significant reduction in body fat, with a significant reduction in waist circumference after thirty-eight months of exercise when compared to the control group. There was also a significant increase for one repetition max (1RM) for all exercises (37). Schroeder *et al*. (42) suggested that whole-body eccentric progressive resistance training results in sizeable gains in muscle strength with modest increases in lean body mass, regardless of training intensity. Thirty-seven, eighteen to twenty-eight year old women completed a sixteen week training program consisting of high resistance training, low resistance training, or the control group two times a week. The absolute and relative gains in 1RM concentric strength increased similarly in both exercise groups, with the exception of the chest press, which was almost twofold greater in the high resistance training group (42). After the sixteen weeks of training, lean mass significantly increased in both exercise groups, with no difference between groups. Fat mass significantly increased in the low resistance training group, while no significant change was demonstrated in the high resistance training group or the control group. Even though strength and lean mass improved in these women, there was no change in BMD. However, there was a significant change in BMC of the spine in the low resistance training group (42).

Maddalozzo and Snow reported no changes in total body lean mass over a three month control period in 263 men and women aged fifty to sixty. However, after the six month training period, total lean body mass was increased significantly regardless of resistance training group (moderate vs. high intensity) or gender (38). Stewart *et al.* (43) revealed a three percent increase in lean mass among exercisers that completed a six month program for men and women aged fifty-five to seventy-five. This increase in lean mass was accompanied by increases in upper- and lower-body strength of seventeen percent and twenty-two percent, respectively (43).

Complex resistance exercises, such as those involving movement at more than one joint (such as the bench press or leg press), may involve a longer initial neural adaptation compared with simpler single-joint exercises, and this may result in delayed hypertrophy of the muscle (44). It has also been recognized that resistance training programs, with exercises performed three to four times per week (instead of two times per week) are optimal for producing muscle hypertrophy (44). Chilibeck *et al.* (44) examined nineteen young women who completed an exercise program of resistance training twice a week for twenty weeks. They demonstrated that training with complex exercises (bench and leg press) causes delayed muscle hypertrophy when compared to a less complex exercise (arm curl) (44). The training group experienced significant increases in 1RM throughout the entire program for all three exercises. However, lean mass only increased during certain times of the training program. During the first ten weeks of training, significant gains in lean mass were in the arms only. Gains in the trunk and legs in lean mass were significant only during the last ten weeks (44). Also, gains in lean mass did not correlate well with gains in strength. Significant correlations were found for gains in the lean mass of legs versus gains in leg press strength during the last ten weeks of the program. Gains in trunk lean mass versus gains in bench press strength were experienced during the first ten weeks of training (44).

McBride *et al.* (45) suggests that multiple sets or a greater volume of resistance exercise yields optimal gains in strength even for relatively untrained persons, especially in simple exercise movements. They reported that six sets promoted significantly greater percentage strength gains in single joint movement. However, neither training volume, single set nor six multiple sets, resulted in a significant change in body composition in the arms or legs. Therefore, it might be possible that the exposure to multiple exercises for the same muscle is necessary to further muscle hypertrophy (45).

Exercise and Bone Density Changes During Lactation

It can be seen from previous research that both lactation and exercise independently affect BMD. However, only two studies have been published showing the effects of both exercise and lactation on BMD. Drinkwater and Chesnut measured bone density changes during pregnancy and lactation in active women, however there was no control group (non-exercising) to compare changes to (2). This study used a small group of women (n = 6) that became pregnant during a longitudinal study of bone mineral density. During the nine months of pregnancy, there was a significant decrease in BMD at the femoral neck and radial shaft of the pregnant women. During the same period the BMD of the tibia increased. The nonpregnant women maintained a constant bone density at the femoral neck and radial shaft, but also experienced an increase in bone density of the tibia. A non-significant decrease was seen in BMD of the lumbar spine in the pregnant women. After six months of lactation, BMD of the radial shaft returned to pre-pregnancy levels, while the femoral neck BMD continued to decline. Tibial density did not change from the postpartum value. The decrease in BMD in the lumbar was similar to previous research of non-exercising lactating women (2). However, it is important to consider that these women were highly trained runners still training during pregnancy and lactation.

The other study by Little and Clapp measured lactation-induced bone loss during early postpartum in women who were participating in recreational exercise, as compared to sedentary controls (35). Self-selected recreational exercise was quantified as an exercise volume ranging from three to six days per week, twenty-five to seventy minutes per session, and fifty-five to seventy-five percent of preconception VO_{2max}. Aerobic, weight-bearing exercise included walking, running, aerobics, step aerobics, and stair machines. However, many subjects also participated in biking, swimming, and resistance training. Changes in bone density in the control and exercise groups were similar in both direction and magnitude, and no significant group by time interaction was observed. BMD decreased significantly in the lumbar spine and femoral neck. Also, no significant relationships were observed between the various bone density measures and selected variables including weight, serum estradiol, dietary calcium intake, and lactation calcium loss (35). This is most likely due to the fact that exercise was not specific enough or met high enough levels of frequency, intensity, and/or duration.

Conclusion

During lactation bone loss often occurs predominantly in trabecular bone at the lumbar spine, femoral neck, total hip, spine, pelvis, and whole body (3,13). Bone mass can also be improved or maintained by resistance exercise, such as weight training, or with aerobic exercise, such as walking or jogging (9,10). There are only two reported studies of the effects of exercise on BMD during lactation. However, they had limitations: one did not have a control group, and neither was randomized. Therefore, the purpose of this study was to determine changes in BMD and body composition as a result of resistance and aerobic exercise of lactating women from three weeks postpartum to twenty weeks postpartum.

CHAPTER III

RESEARCH ARTICLE

INTRODUCTION

Achieving peak bone mass is important to bone health. One achieves peak bone mass by the time they are thirty (1). Achieving and preserving peak bone mass is imperative and can be obtained by a balanced diet rich in calcium and vitamin D, weight-bearing exercise, a healthy lifestyle with no smoking or excessive alcohol intake, talking to one's health care professional about bone health, and bone density testing and medication when appropriate (1).

Bone is lost in two stages of life for women. The rate of bone loss increases after menopause, when the ovaries stop producing estrogen, the hormone that protects against bone loss (1). Bone loss also occurs when women breastfeed their babies. Several studies have shown that women lose three to nine percent of their bone density at trabecular rich sites during lactation compared to pre-pregnancy lactation (2-6). However, it has been shown that most women who lose bone during lactation regain that bone loss after weaning, making breastfeeding a safe feeding choice for their child and themselves (5,7,8).

Bone mass can also be improved or maintained by resistance exercise, such as weight training (9). Aerobic exercise also increases bone mass by using body weight as the resistance. Walking and running are great ways to increase or maintain bone mass while increasing cardiovascular fitness and improving body composition (10).

Currently, there is little research on whether exercise can slow the rate of loss of bone during lactation. One study by Little and Clapp reported no impact on lactation-induced bone loss due to recreational exercise (35). Drinkwater and Chesnut reported bone density changes during pregnancy and lactation in exercising women; however there was no control group with whom to compare these changes (2). Therefore, the purpose of this research project was to assess the effects of exercise on bone mineral density and body composition during lactation. We hypothesized that resistance and aerobic exercise would slow the bone loss during lactation. This may result in enhanced levels of bone mineral density to a level above baseline once mothers stop breastfeeding their infants.

MATERIALS AND METHODS

Design and Protocol

A longitudinal, randomized clinical trial examining the changes in bone mineral density (BMD) and body composition due to exercise during lactation was undertaken as part of an ongoing larger study that will be reported elsewhere. This larger study, Breastfeeding and Exercise for Healthy Infants and Postpartum Moms (BEHIP Mom), is examining the role of exercise on hormonal and biochemical bone turnover marker changes affecting body composition, strength, and bone during lactation. Blood, urine, and breast milk samples were obtained from the mothers pre- and post-intervention. Two diet analyses were completed for each mother pre- and post-intervention. The use of multivitamins and supplements were also discussed as part of the BEHIP Mom study. Mothers also have the possibility to participate in a weaning study where the same measurements in the BEHIP Mom study are performed 5 months after menses resume. Women were evaluated both pre- (4 ± 1 week postpartum) and post-intervention (21 ± 1 week postpartum). Measurements of body composition and bone mineral density were completed during two visits to the Wake Forest University Baptist Medical Center. Cardiovascular fitness, strength assessment, and anthropometric measurements were completed during two visits to the Human Performance Laboratory at the University of North Carolina at Greensboro.

Subjects

A sample of 24 healthy (free from chronic disease and hormonal disturbances), non-smoking, sedentary (exercised less than three days per week during the prior three months) women were recruited from the Guilford County area. They were exclusively breastfeeding (no more than four ounces of formula fed only occasionally) women with a body mass index of twenty to thirty (kg/m^2) at two to three week postpartum. This range was chosen as a normal weight range in order for safety reasons for the subject. Recruitment was optimized by including women aged twenty-three to thirty-seven. Women in this age group should be experiencing less change in bone density compared to a young woman still increasing bone density or an older woman who may be experiencing a gradual decline in bone density. Women were also excluded if birth included a cesarean section because they would not be able to begin the exercise program at four weeks postpartum. Bone density loss may also be different between primiparous and multiparous women. Therefore, we stratified the random assignment to control or intervention groups by parity.

Participants were recruited through fliers (see appendix) posted at local obstetricians' offices, prenatal education classes offered at the Women's Hospital of Greensboro, women's groups at local churches, and by recommendation from midwives in the area. Initial questionnaires (see appendix) were completed over the phone either before delivery or shortly thereafter by a trained research assistant.

Sample size was based on a study of bone loss at the lumbar spine during lactation (14). Power calculations estimated that a final sample size of twenty (ten women per group) would provide significant power to detect a ten percent difference in change in BMD between groups, with the exercise group losing less BMD as a result of the exercise program.

Before admission into the study, all women obtained medical clearance from their personal physician (see appendix). This research project was approved by the Institutional Review Board of the University of North Carolina at Greensboro. Informed consent was obtained from all participants prior to participation (see appendix).

Baseline and Endpoint Measurements

Body composition, anthropometrics, and bone mineral density. BMD and percent body fat were measured at 4 (±1) weeks and 21 (±1) weeks postpartum using dual-energy x-ray absorptiometry (DEXA). Delphi A by Hologic (Version 12.3) was used for all subjects. A quality control was performed every morning with a spine phantom before the machine was used each day. A whole body phantom was performed three times per week. Step phantom and air scans were also performed once per week. Subjects were placed in a supine position while an x-ray beam scanned the entire body at one centimeter intervals. Regional scans included the lumbar spine and the hip region. At twenty weeks postpartum, a pregnancy test was given to all subjects before completing the final x-ray scan. A pregnancy test is unnecessary at the four week test. After birth, menstruation will not resume for at least eight weeks in non-lactating women. During lactation, menstrual cycles may not resume for eighteen months (46). At post-test, a urine sample was collected and the sample was taken to the UNCG Student Health Center to verify that the woman was not pregnant before she had the final bone density measurement by using the Quickvue HCG Combo lab test (Quidel, San Diego, CA).

Weight was measured with light clothing and without shoes on a stationary beam balance (± 0.1 kg). Height was measured by a stadiometer (± 0.1 cm) without shoes.

Strength assessment. The dynamic muscular strength was assessed by determining the one repetition maximum (1 RM) method as described by the American College of Sports Medicine (ACSM) (47). The 1 RM testing was performed one to six days prior to the start of the intervention and 24-48 hours after the conclusion of the sixteen week intervention in order to provide a rest period if the subject was in the EG. Post-intervention 1 RM was measured forty-eight hours after the final training session. Initial assessments of 1 RM were used to determine the starting resistance for each exercise. Exercises were squats, bench press, standing military press, stiff-leg deadlifts, high pulls, pushups, bent over dumbbell row, wall sits, abdominal plank, and abdominal crunches. Subjects warmed-up the muscles to be tested by lifting forty to sixty percent of perceived maximum, five to ten times. After a one-minute rest, five more repetitions were performed at sixty to eighty percent of perceived maximum. After three to five minutes of rest, a small amount of weight was added until the weight could not be lifted. The 1 RM was determined as the last weight successfully lifted.

Cardiovascular fitness assessment. To assess the cardiovascular fitness level of the subjects, a modified Balke protocol submaximal graded treadmill test was used (47). Subjects wore a heart rate monitor (Polar, Inc., Woodbury, NY) throughout the exercise bout, and resting heart rate (RHR) was measured immediately prior to exercise. Submaximal heart rate was determined for each subject using the heart rate reserve formula [(220-age-RHR) x 85% + RHR] (47). To avoid injury, subjects were led through stretching exercises and warmed-up on the treadmill for two minutes. Participants were given the option to run or walk on the treadmill. The treadmill speed was chosen by the subjects, at what they felt was a challenging level. This speed remained constant throughout the test. Heart rate was measured and recorded every minute, as well as level of perceived exertion using a rating of perceived exertion (RPE) Scale. Treadmill grade was increased by two and a half percent every two minutes. Participants exercised until their heart rate reached eighty-five percent of their predicted maximal heart rate, unless discomfort or fatigue was expressed. Predicted oxygen consumption (VO_2) was determined using the formulas of the ACSM as follows (47):

$$VO_2 \text{ (walking)} = (3.5 \text{ ml/kg x min}) + (\text{speed in m/min x } 0.1) + (\text{grade x m/min x } 1.8)$$

$$VO_2 \text{ (running)} = (3.5 \text{ ml/kg x min}) + (\text{speed in m/min x } 0.2) + (\text{grade x m/min x } 0.9)$$

Linear regression was used to determine the subject's predicted VO_{2max} using heart rate as the independent variable and predicted VO_2 as the dependent variable.

Intervention/Exercise Group

After measurements, women were randomly assigned to either an intervention (exercise) group (EG) or the control (minimal care) group (CG). The intervention consisted of aerobic (three days per week) and resistance exercises (three days per week). The intervention group completed a sixteen week home-based exercise program that focused on increasing core strength of the body (i.e. abdominal and back muscles by resistance training and aerobic exercise). Research assistants traveled to participants' homes three days per week to train mothers in the exercise program and to ensure exercise compliance during the study. Compliance was assessed by examining the heart rate monitors at each visit to the home. Heart rate monitors recorded one previous session of exercise, therefore, we could verify that they had performed their exercise on the day that we were not present in the home. Compliance was also assessed by looking at the subjects exercise logs and making sure it was being filled out during each exercise session. We counted the number of exercise sessions completed for aerobic and resistance exercise separately and divided the number completed by the total number of sessions possible (48 sessions possible to complete during the 16 wks for each aerobic and resistance exercise) in order to obtain percentage compliance.

Aerobic exercise. The aerobic program consisted of forty-five minute sessions at an intensity of sixty-five to eighty percent of the women's predicted maximum heart rate. Women wore heart-rate monitors (Polar, Port Washington, NY) to confirm that they were exercising at the prescribed intensity. Duration of aerobic exercise began at five minutes per day, progressing to forty-five minutes per day by increasing the time spent in their target heart-rate range by five minutes each day for the first week and by three minutes per day until forty-five minutes per day was reached. At the beginning of the intervention, when aerobic exercise duration was short, aerobic and resistance training were completed on the same day. Once aerobic exercise duration increased to forty-five minutes a day, beginning at week number five, subjects trained aerobically three days per week and on the alternating days, completed their resistance training for a total of six days per week of training. Each exercise session was started with a five-minute warm-up and ended with a five-minute cool-down period to avoid injury.

Resistance exercise. The resistance program focused on structural exercises that involve direct force through the axial skeleton. Exercises were squats, bench press, standing military press, stiff-leg deadlifts, high pulls, pushups, bent over dumbbell row, wall sits, abdominal plank, and abdominal crunches. All of these exercises were completed in the home with handheld weights and an exercise ball. They were instructed on proper form for all exercises and then performed maximal tests on all exercises prior to the intervention. The subjects were also given a video of the exercises and written explanations of the exercises with figures (see appendix). The training tape was developed specifically for this study with the help of Rick Bloomer and illustrated the exercises from a front and side angle with a model performing the exercises and Mr. Bloomer pointing out tips for proper form.

Progression of the resistance exercise programs were individualized based on their 1 RM. There were three stages of resistance exercise. The first stage was familiarization and lasted for the first week, with one set for all exercises at sixty percent of 1 RM. It included a 3-0-3 tempo: three seconds down, hold for zero seconds, and three seconds up. There was a forty-five to sixty second rest between each exercise with ten to fifteen reps per exercise.

Weeks two through six were the hypertrophy stage, which began with alternating days of the split routine as follows: Day 1 – squats, bench press, standing military press, abdominal crunches, and wall sit; Day 2 – stiff leg deadlift, pushups, high pulls, bent over dumbbell row, and abdominal plank. Exercises were performed at seventy percent of 1 RM, with ten to fifteen reps per set, three sets, 3-0-3 tempo, with forty-five to sixty seconds rest between exercises. Either a straight set method (doing all three sets of one exercise and then moving onto the next exercise) or a superset method (doing all sets of one exercise and then one set of the next until all exercises were done and then cycle back through all exercises until all three sets for each exercise were completed).

The final stage, weeks seven through sixteen, was the strength stage, which continued alternating days of the split routine at eighty-five percent of the 1 RM, with five to eight reps per set, four to five sets, at a 2-0-2 tempo, with two minutes rest between each using the superset method.

Control/Minimal Care Group

The control group was asked not to perform aerobic or resistance exercise more than once per week. They were allowed to walk their babies in strollers at a casual pace, but were not allowed to intentionally exercise at all. They were offered the exercise program after they completed the pre- and post-intervention measurements (at 4 (±1) weeks and 21 (±1) weeks postpartum). This incentive helped in subject recruitment and encouraged women to agree to random assignment.

All women in our study were instructed not to change their dietary intake or restrict calories during the sixteen-week intervention period. Mothers in both groups were asked every two weeks if their menstrual period has returned, if they were using hormonal birth control, and still exclusively breastfeeding.

Statistical Analysis

Data was analyzed with JMP (Version 5.1.1, JMP, Cary, NC) statistical software. Student t-tests were used to determine differences in baseline characteristics; and percent changes in strength, VO_2, and body composition between groups. Significant differences between groups were noted at $p<0.05$ with a trend for significance noted at $p<0.15$. All other p values ($p \geq 0.15$) were considered not statistically significant between the two groups. We are noting a trend for significance because of our small sample size and the importance of biological significance. Even though some changes in our study may not have been statistically significant they may be important as far as each individual is concerned in terms of their bone health and risk or decreased risk of osteoporosis. For example, a 10-20% difference in bone may not be statistically significant, but is quite important when bone health is concerned.

RESULTS

One hundred-and-twenty-four women were initially screened, with 26 ineligible to participate because they did not meet eligibility criteria pre-pregnancy. Of the remaining 98 mothers left, 30 mothers decided not to participate due to personal conflicts after the baby was born (e.g., scheduling issues, returning to work, and not able to commit time to the study). Three women did not participate due to health issues. Twenty-one women were not able to participate due to having a c-section and 20 women were not willing to agree to randomization. A final 24 women were recruited for the study. These results are on women who have completed the study to date (CG: n=6, EG: n=5). To date, the dropout rate was 12.5% (EG: n=1, CG: n=2). Of the 3 dropouts, all women quit due to not being able to continue exclusively breastfeed. No dropouts cited study-related reasons. The following results do not include dropouts.

Women were able to complete 88.7% (range: 71.4-100%) sessions per week for aerobic training sessions, and 98.2% (range: 92.9-100%) sessions per week for resistance training sessions. Resistance exercise attendance is higher most likely because most mothers had the research assistant come on days that they did resistance exercise rather than aerobic exercise days since they did each one on different days.

There were no significant differences between groups in baseline characteristics (Table 1). In addition, there were no significant differences in baseline strength (Table 2), cardiovascular fitness (Table 3), body composition (Table 4), or for bone parameters (Table 5) between groups.

Exercise-Specific Tests

Strength. After 16 weeks, maximal strength change (Table 2; Figure 1) increased by 23-166% for all exercises in the EG, whereas, the CG increased by 0-14%, except pushups (90%). Percent change from baseline was statistically significant between the EG and CG for squats ($p=0.02$), bench press ($p=0.02$), stiff leg deadlift ($p<0.0001$), high pulls ($p<0.0001$), and bent over dumbbell row ($p=0.03$). There was a trend for differences between EG and CG for military press ($p=0.06$), wall sits ($p=0.10$), and sit ups ($p=0.09$).

Endurance and aerobic capacity. After 16 weeks, cardiovascular fitness was maintained or increased in both groups (Table 3). Predicted VO_{2max} increased in both groups with no significant difference between the two groups. Actual relative VO_2 change was 2.0 ± 1.4 ml/kg/min and 3.0 ± 2.3 ml/kg/min for the CG and EG, respectively. Actual absolute VO_2 change was 0.0 ± 0.1 L/min and 0.1 ± 0.1 L/min for the CG and EG, respectively with no significant differences between the two groups. There were no significant differences in changes of resting heart rate, test speed, grade, or duration between groups.

Body Composition

After 16 weeks, actual weight change was decreased in both groups (CG = -3.4 ± 2.1 kg, EG = -3.1 ± 3.3 kg) however, there was no statistically significant difference between groups. There was no significant difference in percent weight change between groups (Table 4; Figure 2). After 16 weeks, actual FM loss was -1.5 ± 5.1 kg and -2.1 ±

2.9 kg for the CG and EG, respectively. There was no significant difference in percent fat mass (FM) percent change between groups (Table 4; Figure 2).

After 16 weeks, there was a trend for higher loss of actual LBM in the CG (-1.9 ± 0.8 vs. -1.0 ± 1.2 kg, p=0.17). There was no significant difference in percent lean body mass (LBM) percent change between groups (Table 4; Figure 2). There was an increase in percent LBM in the EG, even though there was a loss in actual LBM (kg). This increase in percent LBM was due to a decrease in percent FM.

Bone

Bone area. After 16 weeks, total body bone area (BA) percent change (Table 5; Figure 3) was not significantly different between groups. However, there was a trend for an increase in the total LS area percent change from baseline (Table 5; Figure 4) in the EG compared to a decrease in the CG (p=0.09). There was no difference in the lumbar spine vertebrae one (L1) area percent change from baseline between groups (CG = 0.4 ± 3.0%, EG = 1.3 ± 1.6%). There was an increase in lumbar spine vertebrae two (L2) area percent change from baseline in the EG (1.3 ± 1.9%) with a decrease in the CG (-2.3 ± 4.8%) (p=0.14). There was a trend for an increase in lumbar spine vertebrae three (L3) area percent change from baseline in the EG (3.1 ± 3.2%) while there was a decrease in the CG (-0.7 ± 2.6%) (p=0.07). Lumbar spine vertebrae four (L4) area percent change from baseline decreased in both groups (CG = -8.5 ± 4.1, EG = -6.1 ± 5.4%). There was no difference in the total hip area percent change from baseline between groups (Table 5). The femoral neck area percent change from baseline was -0.3 ± 4.7% and 0.4 ± 3.9% for the CG and EG, respectively. The greater trochanter area percent change from baseline was increased in the EG (4.0 ± 8.6%), while there was a decrease observed in the CG (-0.4 ± 1.8%). At the intertrochanteric, area percent change from baseline decreased in the EG (-2.1 ± 8.9%), while an increase was observed in the CG (4.1 ± 9.2%). The Ward's triangle area percent change from baseline increased in both groups (CG = 5.1 ± 17.5%, EG = 2.7 ± 5.6%), however this was not statistically significant between groups.

Bone mineral content. After 16 weeks, total body BMC percent change (Table 5; Figure 5) from baseline decreased in both groups. However, there was a greater loss in the total LS BMC percent change from baseline (Table 5; Figure 6) in the CG compared to the EG and this difference was significant (p=0.004). There was a trend for a greater loss in the L1 BMC percent change from baseline in the CG (-6.6 ± 3.6%) compared to the EG (-1.9 ± 2.4%) and this was statistically significant (p=0.03). There was also a trend for a greater loss in the L2 BMC percent change from baseline in the CG (-8.3 ± 4.1%) compared to the EG (-2.4 ± 3.3%) and this was statistically significant (p=0.03). This trend was also observed in the L3 BMC percent change from baseline (CG = -7.6 ± 3.2%, EG = -1.6 ± 4.0%, p=0.03). L4 BMC percent change from baseline decreased in both groups (CG = -7.0 ± 3.4%, EG = -4.9 ± 4.7%), however this was not statistically significant between groups. The total hip BMC percent change from baseline between groups (Table 5) was not significant. The femoral neck BMC percent change from baseline was -5.1 ± 6.3% and -1.9 ± 3.8% for the CG and EG, respectively. The greater trochanter BMC percent change from baseline was increased in the EG (3.8 ± 13.3%), while there was a decrease observed in the CG (-2.5 ± 3.8%). At the intertrochanteric, BMC percent change from baseline decreased in the EG (-3.9 ± 10.4%), while an increase was observed in the CG (2.4 ± 10.4%). The Ward's triangle BMC percent change from baseline decreased in the EG (EG = -2.5 ± 3.1%) with an increase observed in the CG (CG = 3.8 ± 23.3%), however this was not statistically significant between groups.

Bone mineral density. After 16 weeks, total body BMD percent change (Table 5; Figure 7) from baseline decreased in both groups, but this decrease was not significantly different between the two groups. However, there was a significantly greater loss in the total LS BMD percent change from baseline (Table 5; Figure 8) in the CG compared to the EG. There was a significantly greater loss in the L1 BMD percent change from baseline in the CG (-7.0 ± 2.5%) compared to the EG (-3.2 ± 1.2%) (p=0.013). There was also a trend for a greater loss in the L2 BMD percent change from baseline in the CG (-6.0 ± 2.9%) compared to the EG (-3.5 ± 2.7%) and this was not statistically significant (p=0.18). This trend was also observed in the L3 BMD percent change from baseline (CG = -7.0 ± 2.4%, EG = -4.5 ± 3.7%, p=0.24). L4 BMD percent change from baseline decreased in both groups (CG = -7.3 ± 2.0%, EG = -6.5 ± 3.8%). The total hip BMD percent change from baseline between groups (Table 5) was not significant. The femoral neck BMD percent change from baseline was -4.8 ± 7.1% and -2.2 ± 3.8% for the CG and EG, respectively. The greater trochanter BMD percent change from baseline was decreased in both groups (CG = -2.1 ± 3.6%, EG = -0.4 ± 4.8%). At the intertrochanteric, BMD percent change from baseline also decreased in both groups (CG = -1.6 ± 2.4%, EG = -2.0 ± 3.3%). The Ward's triangle BMD percent change from baseline was -1.9 ± 8.9% and -4.7 ± 6.3% for the CG and EG, respectively and this was not statistically significant between groups.

DISCUSSION

To our knowledge, this was the first study to examine the effects of both resistance and aerobic exercise in lactating women. This program was designed to either slow, stop, or reverse the declining bone loss that has been associated with lactation. The central results of our study are two-fold. First, resistance exercise can increase the strength of breastfeeding women. Secondly, our exercise program did not only slow BMC loss of the LS but also increased its area resulting in less loss of BMD at the LS. It also had positive effects on body composition.

We achieved comparable results in strength changes as compared to results with those of other studies (40,44). All of our exercises, except push-ups and abdominal plank had significant differences in percent change from baseline between groups or were showing a trend for a significant difference. The two that did not show a trend could simply be due to the small sample size of our study which resulted in a lack of power to detect differences. Another reason that the abdominal plank and push-ups may not have significant differences between the two groups could be due to a ceiling effect meaning the subjects will not perform each exercise past a certain point or number. This effect is possible especially considering that we used the same position pre- and post-intervention measurements in order to detect an accurate percent change from baseline even though subjects may have advanced to a more difficult form of the exercises (e.g. moving from the knees to the feet). This is also true considering that the EG had much better, correct form than the CG group making it more difficult to do more push-ups or hold the abdominal plank longer.

We did not detect a statistically significant difference in percent LBM among the exercise and control group. However, there was a trend for the actual LBM change (kg) to be different between groups (CG = -1.9 ± 0.8, EG = -1.0 ± 1.2, $p=0.17$). We had hypothesized an increase in strength and LBM in the exercising women. However, the increase in muscular strength could be due to an improvement of neuromuscular conditions, not an increase in muscle mass as was expected. It would be necessary to lengthen the study to determine if this trend for the less loss of LBM in the exercise group is associated with an increase in muscular mass or neuromuscular adaptations. However, some authors argue that after an initial period of neuromuscular adaptation, strength changes must be associated with muscular hypertrophy (48). Twelve weeks should allow for the strength changes to be associated with muscular hypertrophy and we tried to address this by having our subjects complete a 16 week program. Three recent studies have shown positive increases in lean muscle mass due to resistance exercise in young women (40,41,44). It is possible that there is also an accelerated loss of muscle mass during lactation, especially since changes in bone during lactation tend to behave similar to changes in bone during menopause. Furthermore, our results agree with authors that postulate an accelerated loss of muscle mass and strength during the early phase of menopause (49). Again, a small sample size could have produced a lack of power in order to detect significant differences between groups.

In a study by Lovelady *et al.* (26) that examined the effect of weight loss in overweight, lactating women the diet and exercise group lost 0.8 ± 1.1 kg of fat-free mass, while the control group lost -0.6 ± 1.6 kg. The women in our study lost a little more lean body mass (EG: -1.0 ± 1.2, CG: -1.9 ± 0.8 kg). We think this loss is higher because we started our study earlier in the postpartum period (3 wks vs. 4 wks). Therefore, that loss could be due to diuresis, the natural loss of water after pregnancy and since lean body mass includes water, bone, and muscle this could explain this increased loss as compared to studies starting later in the postpartum period.

There was a significant difference in percent change in BMD and BMC with a trend for significance in BA between the EG and CG at the lumbar spine, but not hip and total body. This may be due to the types of exercises used in our program. Although our program was designed to specifically stress axial compression of the lumbar spine, it was not designed to specifically address other areas. Axial compression was largely applied to the spine and it may have been necessary to develop other exercises to improve the axial compression applied to other parts of the body to ultimately see improvements at the hip and total body. It may have been beneficial to have included or increased the amount of leg exercises, such as, walking, running, jumping, stair climbing, and/or lunges in the protocol. In addition, aerobic exercise was only done three days per week. More days may be needed to see a positive effect at the hip area and total body.

The bone loss in our control group was similar to that of other studies examining the effects of bone loss during lactation of non-exercising women. In our study, the control group experienced a bone mineral density (g/cm^2) loss of -1.8 ± 3.4, -6.9 ± 1.9, and -0.7 ± 1.0% at the hip, lumbar spine, and total body, respectively. In a study by Kalkwarf *et al*. (5) a cohort of lactating women lost -3.9 and -2.8% at the lumbar spine and total body, respectively. In a study by Laskey *et al.* (13) lactating mothers' bone loss was compared to nonpregnant, nonlactating women or formula-feeding mothers. They reported a significant loss of BMD at the spine (-3.96%), femoral neck (-2.39%), hip (-1.51%), and total body (-0.86%) which is similar to our findings (13). In a review by Kalkwarf (4) the percent change in bone during lactation of several studies ranged from -9.8 to -1.1% at the lumbar spine, while a loss of -7.0 to -1.4% was experienced at the femoral neck.

The bone loss in our exercise group was somewhat similar to that of the study by Little and Clapp (35) that examined the effect of self-selected recreational exercise on early postpartum lactation-induced bone loss. Our mothers experienced a bone mineral density loss of -0.3 ± 1.4, -4.6 ± 1.1, -2.3 ± 3.3% at the total body, lumbar spine, and total hip, respectively. Little and Clapp (35) reported no change in bone mineral density for total body measurement, however, they did report a significant decrease of -4.1% at the lumbar spine and -2.8% at the femoral neck.

There is evidence that exercise can result in positive changes to body composition and weight. However, there are some authors that have reported that when exercise-induced weight loss occurred, they also reported negative effects on bone despite the fact that the changes in body weight were small to moderate (<5% over 18 and 48 month, respectively) (50,51). Therefore, weight loss and maintenance of BMD may be contradictory exercise aims.

Endurance and aerobic capacity are not the central end points of this study; however, we expected a significant difference between the two groups. In other studies (26,27) significant improvements have been noted in aerobic capacity, however, these studies had a higher number of sessions of aerobic exercise per week (4-5 vs. 3) than we did for this study. However, due to the high time involvement required by subjects we chose a reasonable training volume (3 d/wk) considering they had resistance training (3 d/wk) as well, in order to ensure compliance and reduce dropout. Another reason that we did not see significant differences between groups could be due to the small sample size of our study. However, when examining absolute VO_2 (L/min) independent of weight, the CG experienced no change in cardiovascular fitness, while there was a slight increase in the EG. Again, sample size may be preventing a significant difference between the two groups.

Overall, our study design possesses several strengths: 1) the exercise attendance and compliance during the study was high. 2) The exercise program was attractive, which can be eluded from the fact that our dropout rate was not due to the exercise intervention, but rather feeding issues and the rate of dropout was lower among EG and CG. 3) The study was well controlled. At baseline, there were no differences between EG and CG for relevant parameters. 4) The exercise intensity was constantly increased during the intervention period.

Due to time and funding constraints, this study does have limitations. One of the limitations associated with this study is the small sample size. Due to the small sample size, there may not be statistically significant changes because the changes that do occur are so small. Other limitations include compliance issues and the feasibility of this type of exercise intervention being applicable to the everyday population. We had a reasonable compliance rate (aerobic: 88.7%, resistance: 98.2%), however, these mothers had someone coming to their house at a scheduled time to act as a personal trainer and childcare provider. Not having this benefit of the study makes it more difficult for the mother to continue with this type of exercise without outside support.

It also would have been beneficial to have seen a bone scan that shows bone shape and size in order to better determine risk for osteoporotic fractures. The shape and size of the bone determine the strength of the bone and that is what is ultimately important in preventing fractures. Certain exercises may be capable of changing the size and shape of the bone in order to reduce risk of osteoporotic fractures.

We showed that a resistance and aerobic exercise program has the potential to slow BMC loss and increase bone area of the LS resulting in less loss of BMD during lactation. Resistance and aerobic exercise are beneficial in achieving and preserving peak bone mass. This is imperative in order to reduce the risk of osteoporosis.

CHAPTER IV

EPILOGUE

If I had more time and money I would continue this study post-weaning. This is being done in a follow-up study, but I would continue working out with moms that were in the exercise group and start working out with those in the control group that wish to start exercising. I would have also incorporated a larger sample size in this study in order to achieve more statistically significant differences between groups. I think that if we had added more leg exercises we might have seen significant changes in bone at the hip and possibly total body. I would have incorporated box jumps, lunges, and/or stair-steps because these exercises specifically place force at the hip and this is why I would have incorporated these exercises along with our other exercises. I think we should have included more days of aerobic exercise in this study in order to have seen a significant difference of aerobic capacity between groups. However, in order for mothers to complete more days of aerobic exercise I think it would be necessary for a research assistant to either be at the house for childcare purposes or to actually do the aerobic exercise with them on a daily basis. This was a great study; however, it is difficult for these mothers to continue this workout without our help or support from others.

There were no differences between groups in any baseline measurements. After examining the outcomes of my hypothesis, that exercising women will have experienced less total BMD loss than sedentary women as a result of the exercise intervention, the hypothesis was not rejected. This is especially true at the LS; however, there was no statistical difference at the hip or total body. While taken into consideration the small sample size this does prove as an effective method to slow the loss of bone at the lumbar spine (LS). This hopefully would reduce the risk of osteoporosis.

Based on the results the hypothesis that the exercising women will have experienced greater weight loss than sedentary women as a result of the exercise intervention due to a reduction in fat mass was also not rejected. I also hypothesized that these women will have experienced greater gains in lean body mass than their sedentary counterparts. We reported similar weight loss in both groups; however, the exercise group did lose more fat mass than the control group. Nevertheless, this fat mass loss was not statistically significant between groups. The exercise group did show a trend for gaining more lean mass than their sedentary counterparts; however this was not statistically significant either.

Based on the results the hypothesis that the exercise group will have improvements in both cardiovascular fitness and muscular strength as a result of the exercise intervention was also not rejected. This did not hold true for the cardiovascular fitness, however, I think this was due to the lower number of days of aerobic sessions per week when compared to other studies. We did report significant differences in muscular strength in the exercise group, and this was statistically significant.

When looking at the outcomes of this study it is important to take into consideration several aspects. First, many of our mothers returned to work quite early and while they were still able to exclusively breastfeed they may not be fully lactating due to not pumping their milk often enough while they are at work. It is very important to stimulate milk production as if the child were feeding even if the mother chooses to pump, otherwise the milk production will decrease and the mother may not behave as other mothers that are fully lactating. Also, some of our moms began supplementing their children with cereal before six months of age. Most of these moms chose to mix this cereal with breast milk; however, at least one did not. We still classified this mom as fully lactating because we believe this cereal was added as an additional meal in order to help the child sleep throughout the night.

There are many things that would be interesting to analyze given that the materials to do this and the money were available. One thing that I think would be very interesting to examine is bone strength by measuring the size and shape of the bones in order to determine the true risk of osteoporosis. Most osteoporotic fractures occur due to falling and if the bones are stronger then there would be a decreased risk of that bone being fractured if the individual does happen to fall. It would be very interesting to determine if exercise could in fact not only increase bone area, bone mineral content, and bone mineral density, but also bone strength.

One of the most difficult parts of this study was recruitment. Finding subjects that met the criteria (did not live too far away, were going to breastfeed long enough, did not have a c-section, and were willing to randomize) was difficult. Also, there were many first time mothers that thought this would be too much to commit to and either decided not to participate or were happy to be randomized to the control group.

However, after talking to several mothers once they were finished they did agree that it was a huge time commitment, but were glad to be a part of this study.

Although this study was very time consuming and had its difficulties I enjoyed it immensely. It provided me with experiences that I never thought possible. To develop a relationship with these mothers was truly heartwarming. To watch their children grow and develop and interact with the older children was a joy. Every time I seemed to be getting worn out or tired a mother would comment on how excited she was to be losing weight or actually be below pre-pregnancy weight and that would pick me up and motivate me to continue. Not only were these my subjects, but a lot of these mothers became my friends. It was like helping your friends lose the baby weight while spending time having “girl talks” about the children and other various topics. Though I am glad to be graduating and finishing my thesis, I will miss working with this population and hope to do so again in the near future. I will also never forget all that I have learned about life in general and raising a family that these mothers taught me.

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APPENDIX A

TABLES AND FIGURES

Table 1. Baseline characteristics of exercise and control groups.*

	Control Group	Exercise Group
Variable	**Baseline**	**Baseline**
Age (yr)	30.8 (2.5)	31.4 (2.1)
Parity	1.5 (0.5)	2.4 (0.9)
Pre-preg. wt (kg)	60.7 (12.1)	69.5 (11.7)
Height (cm)	165.3 (10.3)	164.7 (4.6)
Starting wt (kg)	69.9 (15.2)	75.1 (5.6)
Starting BMI (kg/m^2)	25.3 (3.1)	27.8 (3.2)

* Mean (SD)
No statistically significant differences between groups for all measures

Table 2. Strength measurements of exercise and control groups.*

	Control Group			Exercise Group		
Variable	**Baseline**	**Endpoint**	**% Δ**	**Baseline**	**Endpoint**	**% Δ**
Squats (lbs)	63.3 (18.6)	70.0 (25.3)	9.4 (10.4)	60.0 (12.2)	84.0 (8.9)	43.1 (19.9)[a]
Bench press (lbs)	37.3 (9.1)	37.3 (9.1)	0.0 (0.0)	38.0 (4.5)	58.0 (8.4)	55.0 (32.6)[a]
Abdominal plank (sec)	56.5 (27.6)	59.2 (36.4)	10.5 (42.2)	72.6 (66.6)	72.8 (52.6)	66.3 (147.4)
Military press (lbs)	32.3 (6.4)	34.0 (6.9)	5.6 (13.6)	34.0 (5.5)	42.0 (8.4)	23.3 (13.7)[b]
Stiff leg deadlift (lbs)	66.7 (17.5)	70.0 (27.6)	2.4 (13.9)	60.0 (10.0)	92.0 (13.0)	54.0 (7.5)[a]
Push-ups (#)	9.4 (7.7)	12.8 (8.8)	90.0 (211.2)	10.0 (6.5)	22.0 (6.2)	166.2 (90.6)
High pulls (lbs)	38.3 (7.5)	41.7 (11.7)	7.5 (11.7)	42.0 (8.4)	64.0 (11.4)	53.3 (10.3)[a]
Bent-over DB row (lbs)	46.7 (15.1)	46.7 (10.3)	3.2 (15.8)	40.8 (20.3)	66.0 (18.2)	80.5 (52.2)[a]
Wall-sit (sec)	36.5 (19.6)	44.2 (34.7)	3.7 (41.3)	23.6 (20.2)	36.2 (11.9)	131.3 (133.0)[b]
Sit-ups – crunches (#)	75.2 (92.4)	85.0 (106.5)	13.5 (11.0)	41.0 (21.4)	70.6 (30.2)	97.8 (83.8)[b]

* Mean (SD)
$p > 0.05$ for baseline values
[a] Significantly different from control group, $p<0.05$
[b] Showing a trend for significance, $p<0.10$

Table 3. Cardiovascular fitness of exercise and control groups.*

	Control Group			Exercise Group		
Variable	**Baseline**	**Endpoint**	**% Δ**	**Baseline**	**Endpoint**	**% Δ**
Predicted VO_2 (ml/kg/min)	31.9 (4.2)	33.8 (4.4)	6.3 (4.6)	30.3 (3.2)	33.3 (4.2)	9.8 (7.8)
Predicted VO_2 (L/min)	2.2 (0.6)	2.3 (0.6)	0.7 (6.6)	2.3 (0.2)	2.4 (0.3)	4.8 (6.5)
Test duration (min)	12.0 (2.6)	14.0 (3.1)	17.1 (9.1)	11.2 (2.3)	12.4 (2.6)	11.7 (16.2)
Resting Heart Rate (RHR)	68.8 (3.9)	69.3 (7.8)	0.6 (8.7)	70.8 (7.1)	68.6 (6.8)	-2.7 (10.1)
85% predicted max HR	171.2 (2.5)	171.0 (2.8)	---	170.8 (2.9)	170.6 (2.4)	---
HR at end of test	170.5 (6.7)	176.5 (5.0)	3.7 (5.1)	173.2 (3.1)	176.0 (5.1)	1.6 (3.3)
Test speed (mph)	2.7 (0.4)	2.8 (0.5)	0.7 (8.5)	2.9 (0.4)	3.0 (0.5)	4.5 (14.8)
Highest grade (%)	12.9 (3.7)	15.0 (3.9)	0.7 (8.5)	11.5 (2.9)	13.0 (3.3)	4.5 (14.8)

* Mean (SD)
$p > 0.05$ for baseline values
No statistically significant differences between groups for all measures

Table 4. Body composition of exercise and control groups.*

	Control Group			Exercise Group		
Variable	**Baseline**	**Endpoint**	**% Δ**	**Baseline**	**Endpoint**	**% Δ**
Weight (kg)	69.9 (15.2)	66.5 (16.2)	-5.3 (3.8)	75.1 (5.6)	72.0 (8.5)	-4.4 (4.3)
Fat mass (FM)						
kg	24.8 (7.3)	23.3 (7.9)	-6.9 (8.2)	27.9 (7.1)	25.7 (8.8)	-9.0 (10.2)
% FM	35.0 (3.3)	34.4 (3.6)	-1.8 (5.1)	36.8 (7.4)	35.1 (8.6)	-4.9 (6.8)
Lean Body Mass (LBM)						
kg	45.1 (8.2)	43.2 (8.4)	-4.5 (2.2)	47.3 (3.7)	46.3 (3.8)	-2.1 (2.6)
% LBM	65.0 (3.3)	65.7 (3.6)	0.9 (2.5)	63.2 (7.4)	64.9 (8.6)	2.5 (4.0)

* Mean (SD)
$p > 0.05$ for baseline values
No statistically significant differences between groups for all measures

Table 5. Bone characteristics of exercise and control groups.*

	Control Group			Exercise Group		
Variable	**Baseline**	**Endpoint**	**% Δ**	**Baseline**	**Endpoint**	**% Δ**
Total Body						
Area (cm^2)	1943.6 (211.2)	1928.3 (214.4)	-0.8 (0.8)	1984.6 (115.6)	1984.5 (125.3)	0.0 (1.1)
BMC (g)	2114.6 (353.8)	2082.6 (352.8)	-1.5 (1.0)	2201.2 (240.2)	2195.2 (254.8)	-0.3 (1.3)[b]
BMD (g/cm^2)	1.08 (0.11)	1.08 (0.10)	-0.7 (1.0)	1.10 (0.07)	1.10 (0.07)	-0.3 (1.4)
Total Hip						
Area (cm^2)	31.5 (3.8)	32.0 (3.1)	2.1 (5.2)	31.6 (3.4)	31.2 (2.1)	-0.2 (5.2)
BMC (g)	30.0 (7.1)	29.7 (5.4)	0.3 (7.8)	31.6 (3.8)	30.8 (3.7)	-2.4 (7.4)
BMD (g/cm^2)	0.94 (0.14)	0.92 (0.11)	-1.8 (3.4)	1.00 (0.08)	0.98 (0.09)	-2.3 (3.3)
Total Lumbar Spine (LS)						
Area (cm^2)	57.8 (8.5)	57.4 (8.5)	-0.6 (2.7)	54.3 (8.3)	55.3 (8.8)	1.8 (1.2)[b]
BMC (g)	64.4 (3.9)	59.7 (13.1)	-7.4 (2.4)	60.0 (12.3)	58.2 (12.0)	-2.9 (1.0)[a]
BMD (g/cm^2)	1.11 (0.13)	1.03 (0.11)	-6.9 (1.9)	1.10 (0.10)	1.05 (0.08)	-4.6 (1.1)[a]

* Mean (SD)
$p > 0.05$ for baseline values
[a] Significantly different from control group, $p<0.05$
[b] Showing a trend for significance, $p<0.15$

Figure 1. Percent Change From Baseline of Strength By Group.

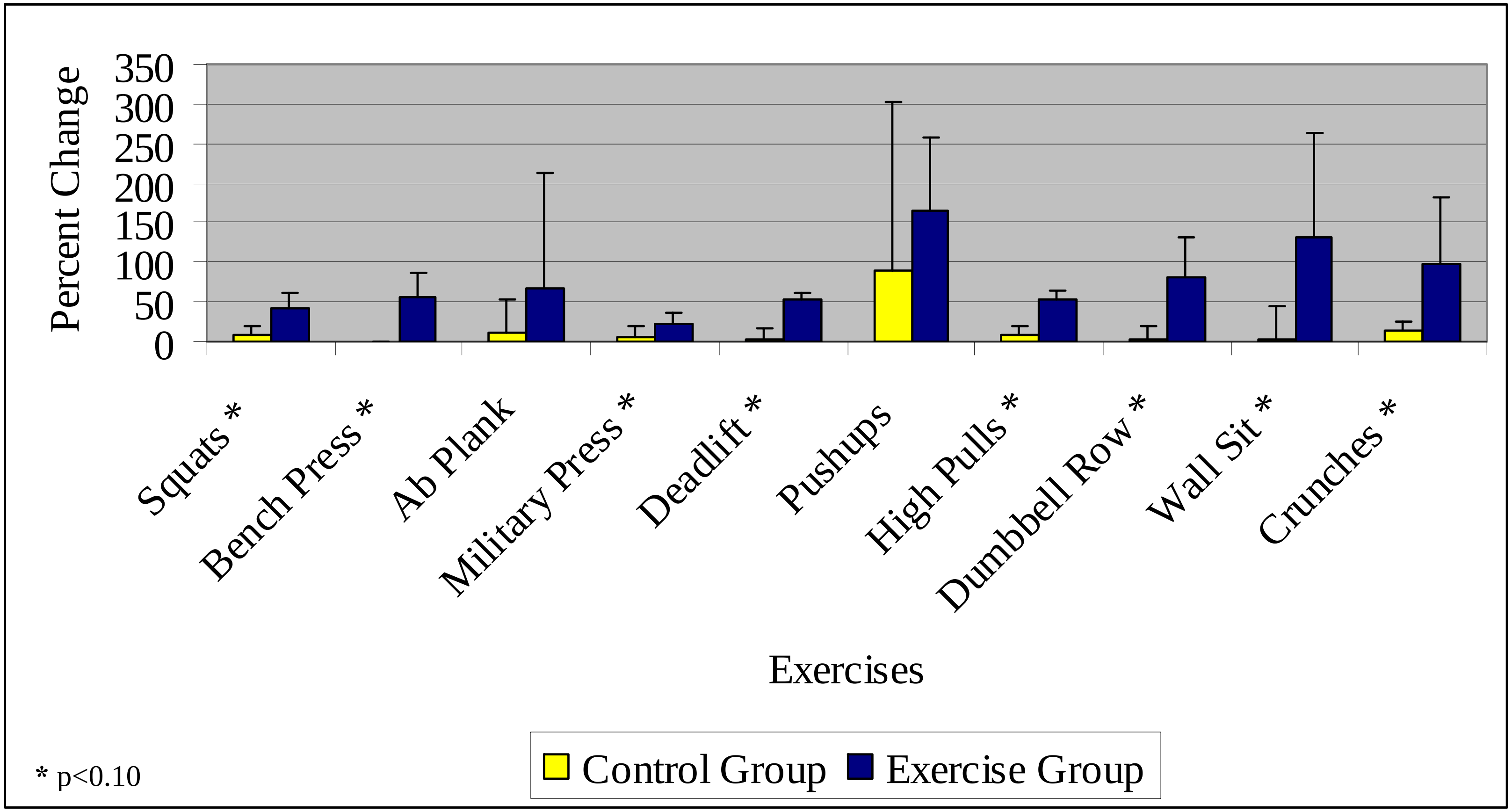
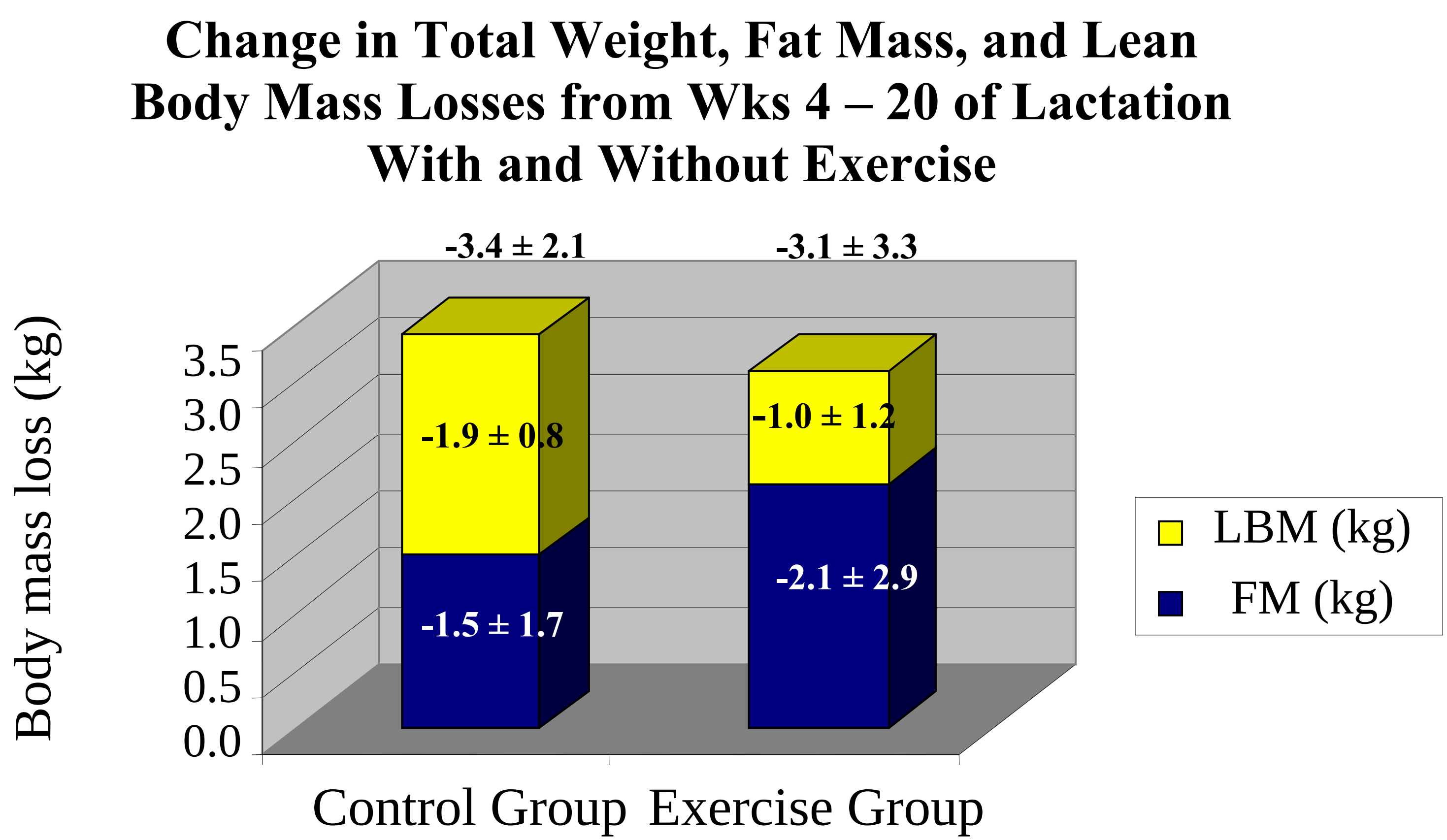
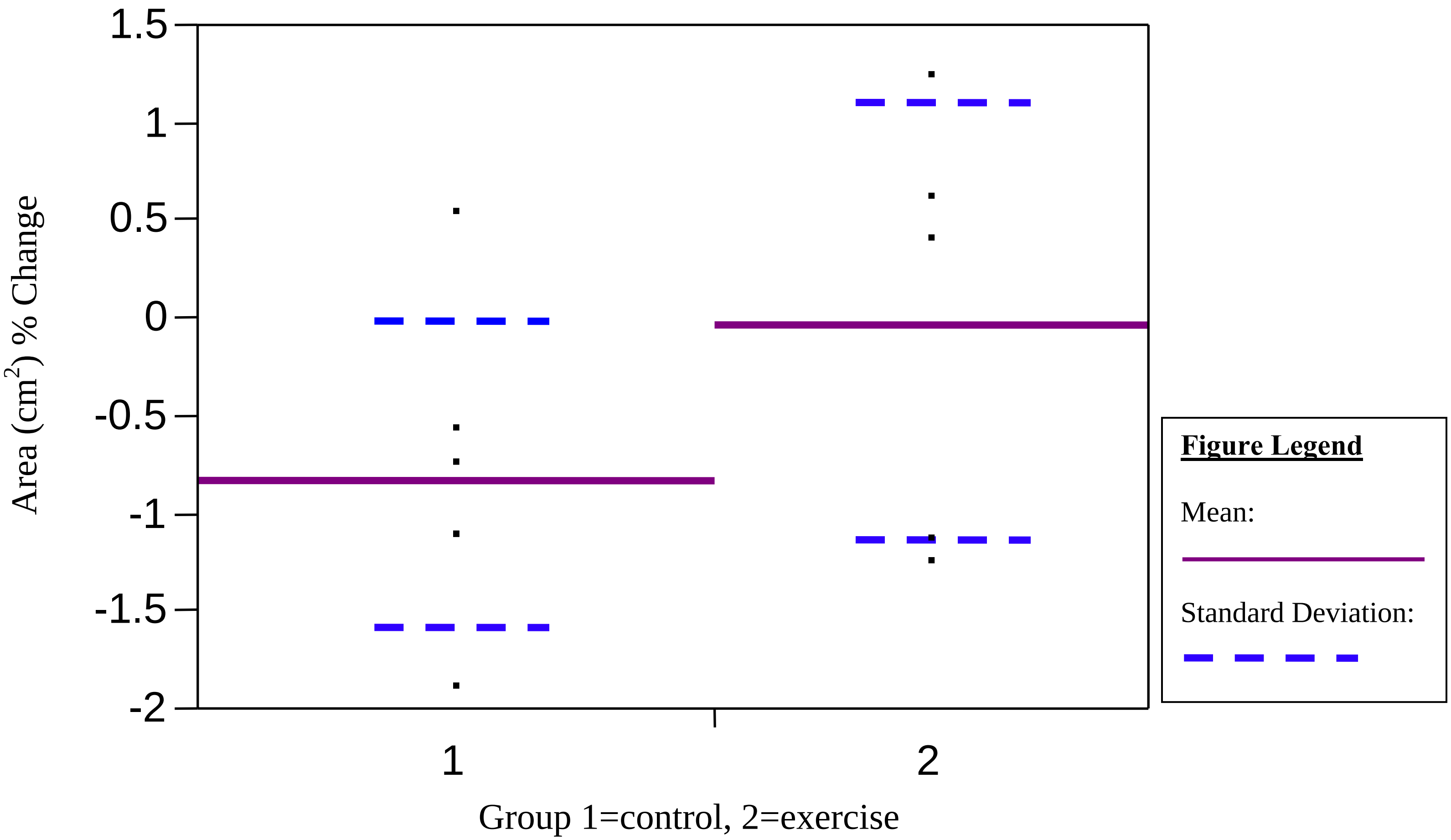


Figure 2. Composition of Weight Loss (kg) Among Subjects.



No statistically significant differences between groups for all measures

Figure 3. Total Body Area (cm^2) Percent Change By Group.



p=0.22

Figure 4. Total LS Area (cm^2) Percent Change By Group.

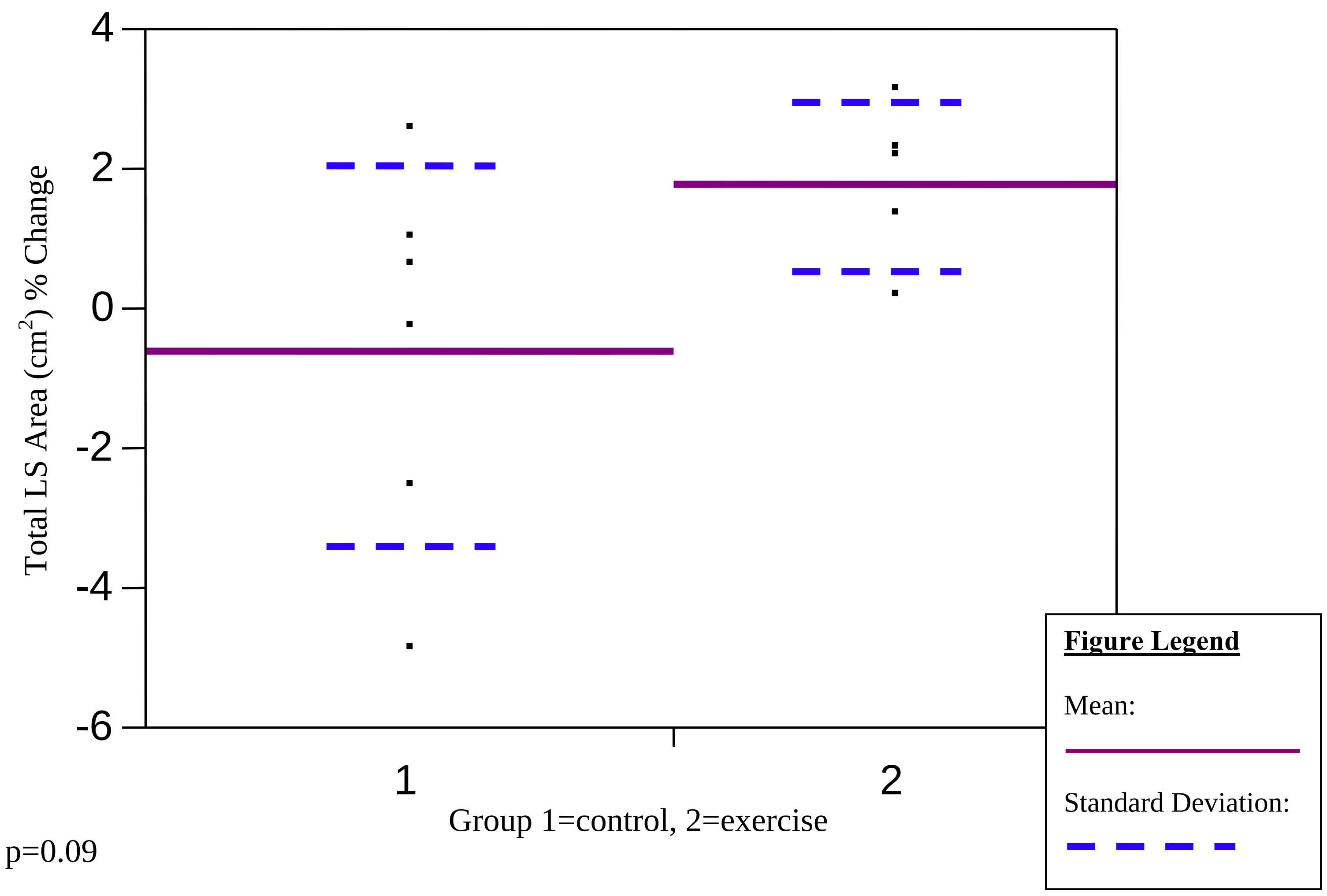
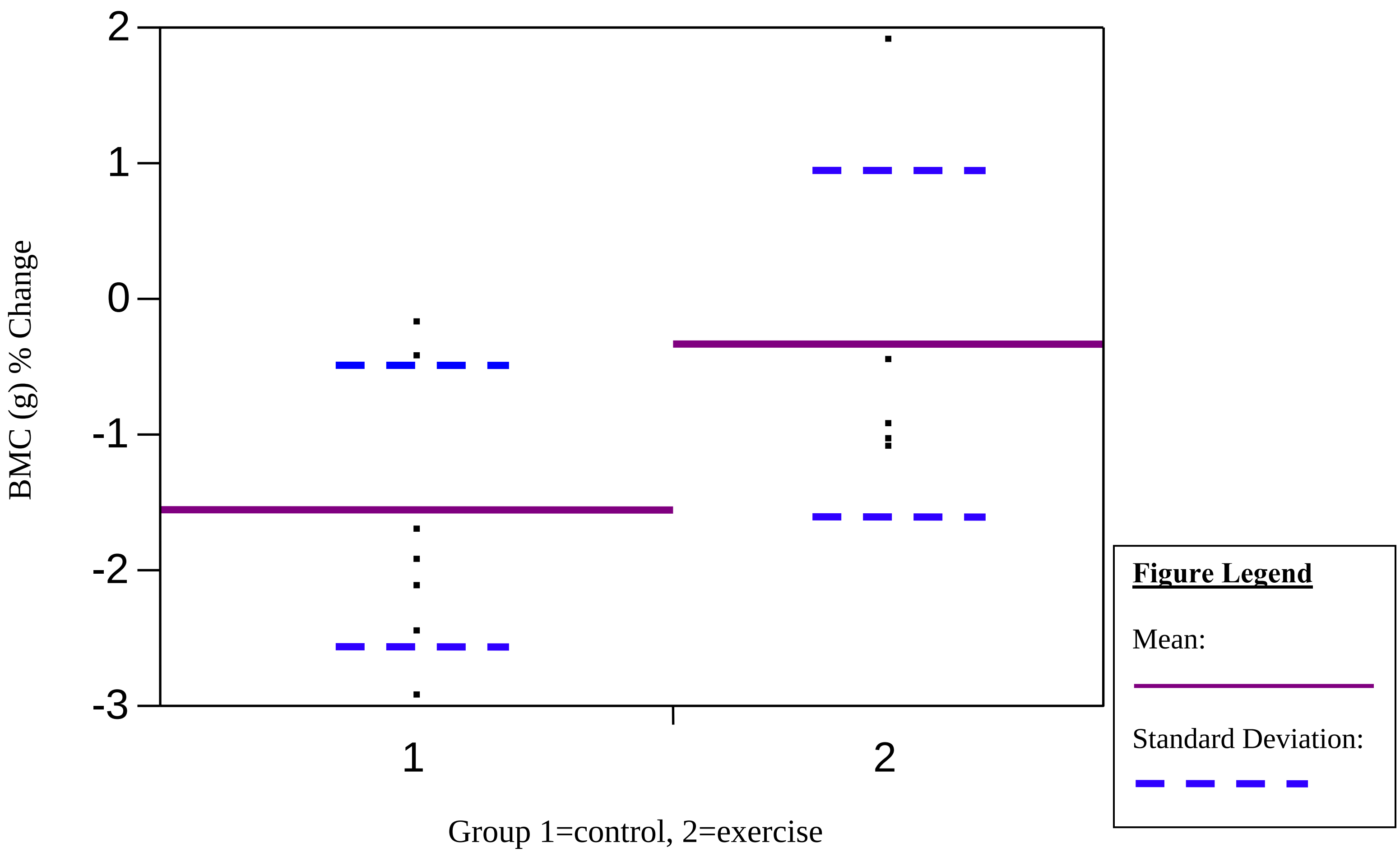
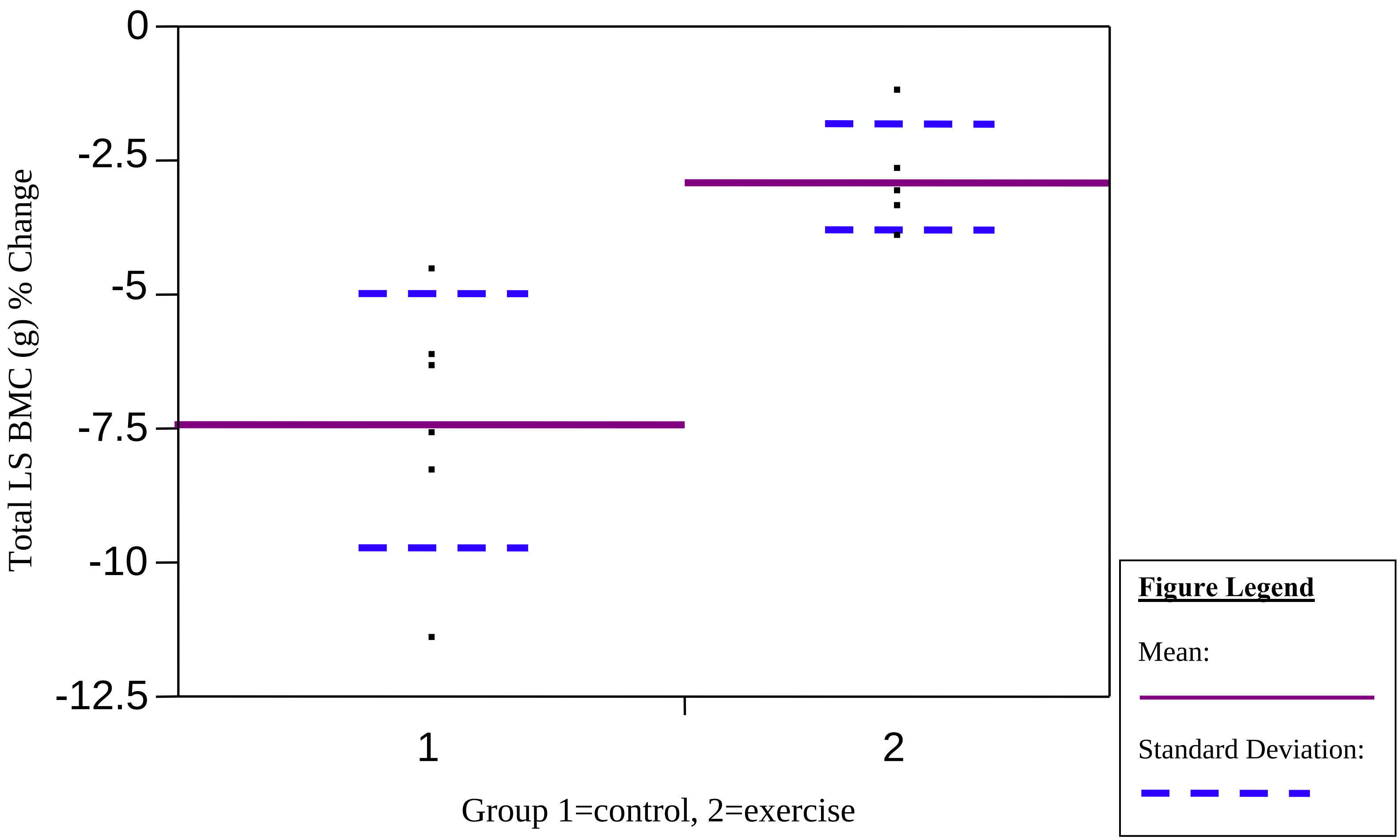


Figure 5. Total Body BMC (g) Percent Change By Group.



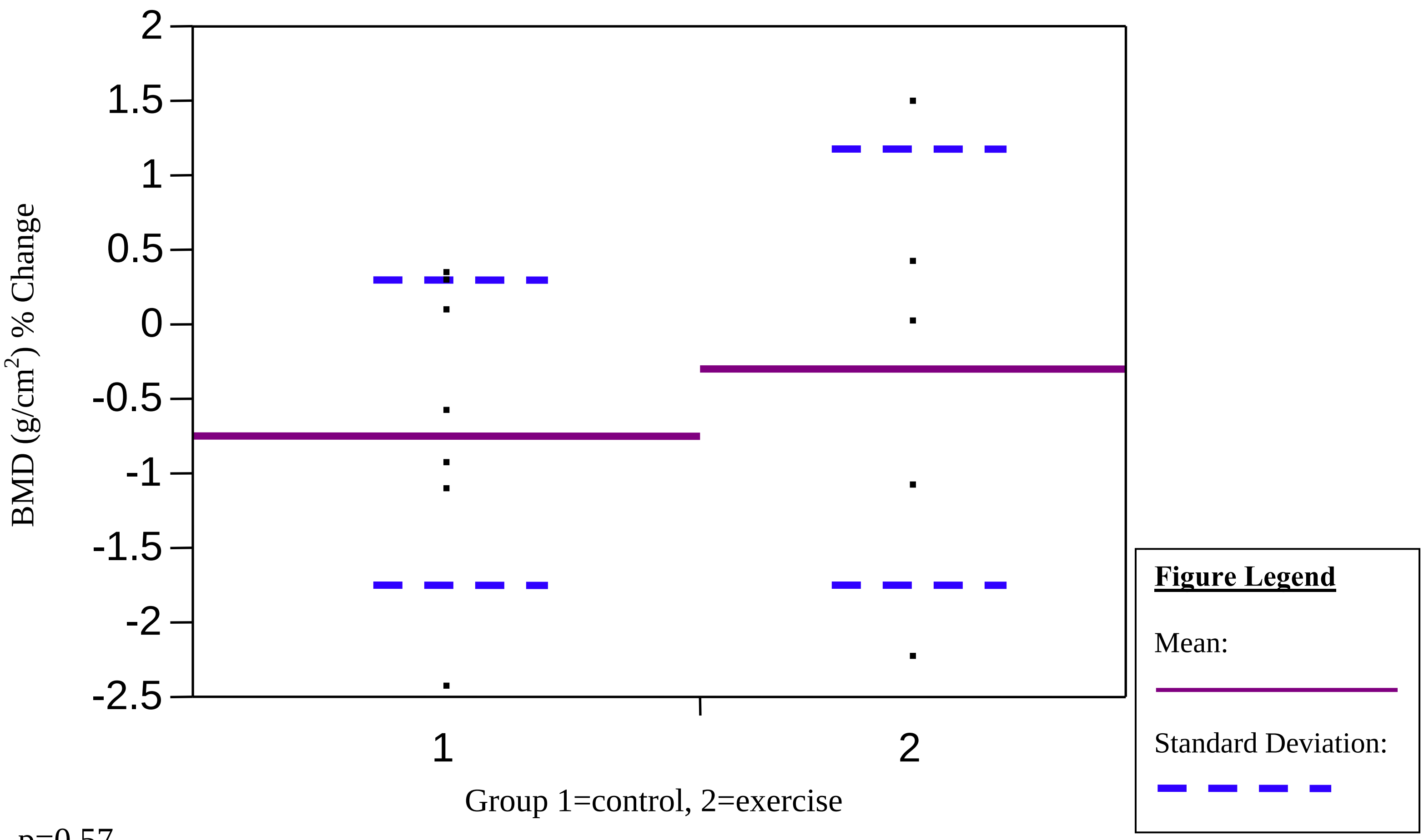
p=0.12

Figure 6. Total LS BMC (g) Percent Change By Group.



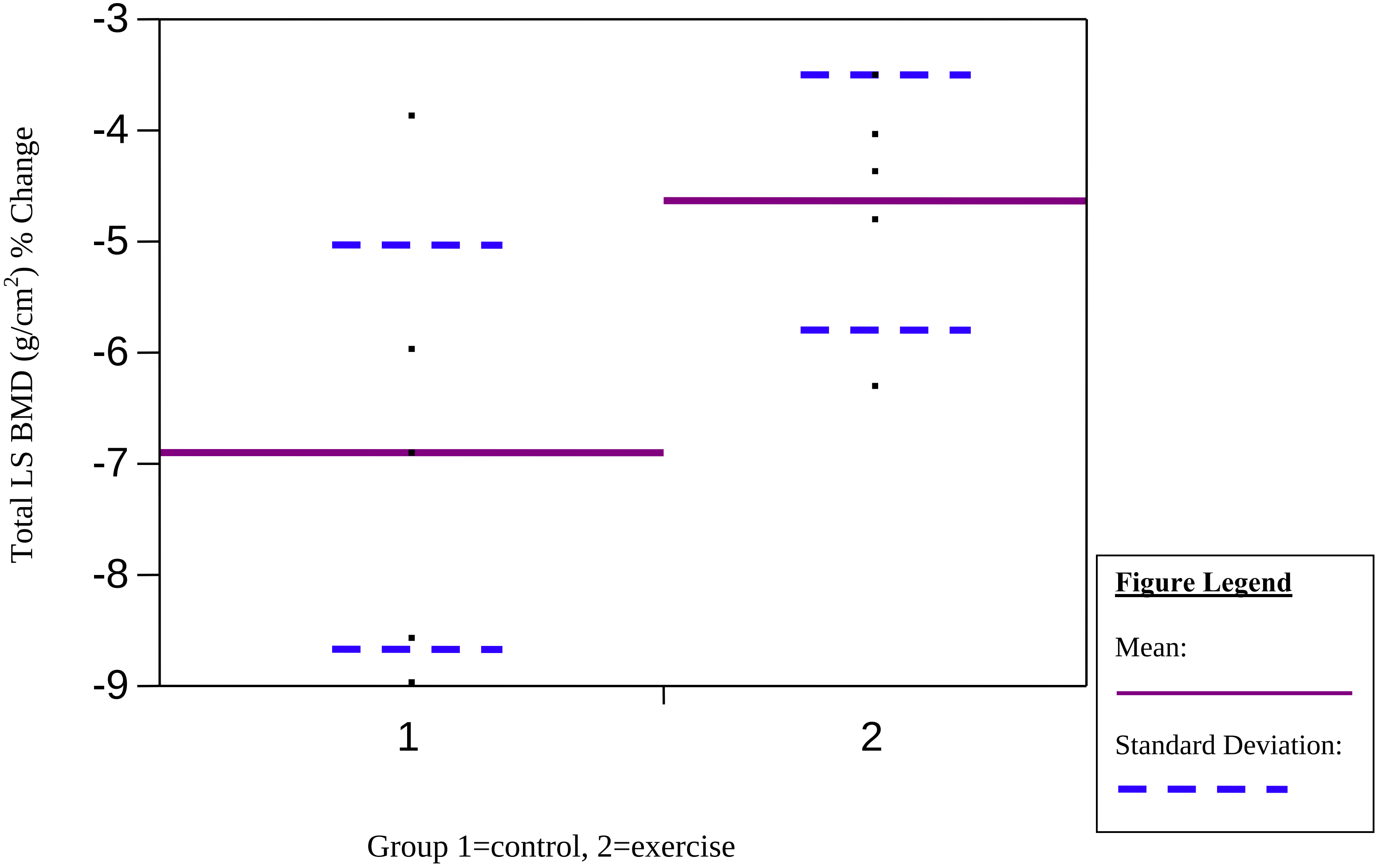
p=0.004

Figure 7. Total Body BMD (g/cm^2) Percent Change By Group.



p=0.57

Figure 8. Total LS BMD (g/cm^2) Percent Change By Group.



p=0.03

APPENDIX B

INFORMED CONSENT AND MEDICAL CLEARANCE FORMS

UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

Consent to Act as a Human Subject

PARTICIPANT'S NAME ____

DATE OF CONSENT ____

PROJECT TITLE: Effect of Exercise Training During Lactation on Mother's Bone Status

INVESTIGATORS: Cheryl Lovelady Ph.D., R.D., Laurie Wideman Ph.D., Melanie Bopp, and Heather Kennedy

DESCRIPTION AND EXPLANATION OF PROCEDURES: The purpose of this study is to determine the bone status of the lactating mother as a result of resistance and aerobic exercise training. The study will begin two to three weeks after you deliver and will continue until you are at your twentieth week postpartum. If you consent to participate, you will be assigned by chance to one of two groups. The first group will participate in the measurements and the exercise program. If you are assigned to the other, or control group, you will participate in all the measurements described below but will not participate in the exercise program. After completion of the project, the control group will be offered the opportunity to learn the procedures used in the experimental group to promote increased bone status through a personalized exercise prescription.

Participants in both groups will be asked to do the following:

1. Receive medical clearance from your physician, through the form provided, to participate in the exercise program.
2. Participate in three short dietary recall sessions. You will be called three times in one week at your convenience at the beginning and end of the study. This diet record will be used to determine your nutritional intake.
3. At 2 to 3 weeks and at 20 weeks postpartum you will be given a body scan by dual energy x-ray absorptiometry (DEXA). This whole-body scan is necessary to determine your bone density. The scan will be completed at the J. Paul Sticht Center on Aging at the Wake Forest University Medical Center in Winston Salem. You will lay still and flat on an x-ray table, and the scanner will move back and forth several feet above you. The entire procedure takes approximately 30-45 minutes, depending on your height. Your breast milk will not be affected by the DEXA scan.
4. At 20 weeks postpartum, you will be given a pregnancy test to ensure that you are not pregnant when the DEXA scan is administered.

(Continued on next page)

5. Visit the Human Performance laboratory at UNCG for several measurements at the beginning (4 weeks) and end (20 weeks) of the study. This visit should take less than 2 hours.
    a) Your height and weight will be recorded first.
    b) Then your cardiovascular fitness will be determined through an exercise test on a treadmill. You will walk or run on the treadmill, beginning at a low level, and will increase until you reach 85% of your calculated maximum heart rate. A researcher certified in cardiopulmonary resuscitation (CPR) will be present at the exercise session. Heart rate and rating of perceived exertion will be measured throughout this test.
    c) You will be asked to provide approximately 4 tablespoons of venous blood after an overnight fast (no alcohol for 24 hours prior to blood draw). The blood will be drawn in the morning at the lab. Venipuncture will be performed by a trained phlebotomist. The blood is needed to assess your bone status.
6. Muscular strength will be assessed at the beginning and end of the study. We will be testing the strength of your muscles using hand weights.
7. You will be asked to collect a small urine sample in the morning on the day of your visit to the lab. The first void of the morning is preferable. You will collect the urine sample into a sterile urine collection cup, and will need to store the sample in your home refrigerator until you come into the lab. You will bring the sample with you to the lab.
8. During the morning feeding on the day you visit the lab, you will collect approximately 4 tablespoons of breast milk. While the infant is nursing on one breast, the milk sample will be obtained from your other breast (a breast pump will be provided if needed). All samples must be chilled immediately in household refrigerator. You will bring the sample with you to the lab.
9. After 20 weeks of the study, you will be asked to repeat all of the measurements above.

Those assigned by chance to the exercise group will also be asked to do the following:

1. Participate in resistance exercise sessions (30-45 minutes) three times each week at your home. All necessary equipment will be provided. A video will be provided for instruction on proper weight training technique. You will also participate in aerobic exercise sessions (45 minutes) three times a week. A qualified research assistant certified in CPR and educated on proper resistance training technique will be present at exercise sessions at least 3 times a week to monitor your training technique (to prevent injury), exercise intensity level, and heart rate.

(Continued on next page) ________________________

Your Initials

2. Participate in strength tests every six weeks to determine any necessary changes to your personalized resistance-training program.

RISKS AND DISCOMFORTS: The risk of injury during exercise exists for you; temporary muscle fatigue and/or respiratory discomfort may result from the graded exercise test. Exercise sessions may result in temporary muscle soreness. Insertion of the needle during venipuncture may be slightly painful. Every precaution will be taken to minimize the risks involved with venipuncture (air emboli, infection, bruising, and fainting). You will be exposed to very mild radiation from the DEXA scan, equivalent to 1/10 the exposure from a routine chest x-ray, and less than the exposure of a dental x-ray. There is no risk to your breast milk.

POTENTIAL BENEFITS: Results of all the tests conducted will be provided to you at no cost. Mothers participating in the study will undergo two free bone density scans, which provide valuable bone density and body composition information. All participants will receive, at no cost, a stability ball, hand weights, and video for home exercise; however, women in the control group will not receive these materials until completion of the study. Benefits to the exercising mothers also include the potential for increased cardiovascular fitness, increased muscular strength, and increased lean muscle tissue.

COMPENSATION/TREATMENT FOR INJURY: In the case of injury, you will be referred to your personal physician for treatment. You are responsible for paying for your treatment for injury. Upon completion of the study, you will receive a $50 stipend.

CONSENT: Your signature on this consent form indicates that you have read the procedures, risks and benefits involved in this research. You are free to refuse to participate or to withdraw your consent to participate in this research at any time without penalty or prejudice; your participation is entirely voluntary. Your privacy will be protected because you will not be identified by name as a participant in this project. All collected data will be stored in a locked file cabinet and will be shredded when it is no longer needed.

The research and this consent form have been approved by the University of North Carolina at Greensboro Institutional Review Board that ensures that research involving humans follows federal regulations. Questions regarding your rights as a participant in this project can be answered by calling Eric Allen at (336) 334-5878. Questions regarding the research itself can be answered by Dr. Cheryl Lovelady by calling (336) 256-0310. Any new information that develops during the project will be provided to you if the information might affect your willingness to continue participation in the project.

(Continued on next page) ________________________

Your Initials

By signing this form, you are agreeing to participate in the project described to you by

____

________________________________ ________________________________
Subject's Signature Witness to Signature

MEDICAL CLEARANCE FORM

APPLICANT'S SIDE

This form is required for acceptance in the lactation study and must be completed by you and your attending physician. This information along with your physician's statement will be used for your participation in a graded exercise test and for prescription of an exercise program. Please check any of the conditions that apply to you.

Name (Print) ____

Age ______________ **Weight** ________________ **Height** _________________

1. Do you have any of the following risk factors for heart disease?

______Inactive lifestyle	______High Blood Triglycerides
______Stressful lifestyle	______High Blood Cholesterol
______Stroke	______High Blood Pressure
______Diabetes Mellitus	______Obesity

______Smoke Cigarettes (if yes, # per day _____)

______Heart disease in family (if yes, please specify __________________)

2. Have you ever experience any of the following?

______Chest pain	Discomfort/pain in the: _____throat
______Chest Pressure	______wrist
______Palpitations/skipped heart beats	______elbow
	______teeth
	______jaw

3. Do you have or has a physician diagnosed you as having any of the following?

______Heart murmur	______Chronic Bronchitis
______Musculoskeletal problems	______Emphysema
______Arthritis	______Neurological problems
______Asthma	______Allergies

______Other (explain):_______________________________

4. Have you ever undergone surgery for any of the following?

______Varicose veins	______Leg surgery
______Abdominal Surgery	______Hernia repair
______Musculoskeletal	______Other (explain):____________

5. Have you ever had any of the following tests?

______Exercise Stress test	______Coronary Angiography
______Echocardiogram	______Holter Monitor

______Exercise Stress test with Isotope

6. Please list all medications/supplements that you are taking.

Name of medication	Dosage	Doses/Day
____________________________	______________	______________
____________________________	______________	______________

7. Are you taking any diet pills or ephedra for weight loss? YES NO

8. Did you exercise vigorously before pregnancy? (circle one) YES NO

9. Did you exercise regularly during your third trimester? (circle one) YES NO

____ _____________________

Applicant’s Signature Date

MEDICAL CLEARANCE FORM

PHYSICIAN'S SIDE

Please check and/or comment on additional history and all pertinent physical findings. This information will be used for the applicant's participation in a graded exercise test and exercise program.

Name of Applicant (print) ____

Name of Physician (print) ____

Physician's Telephone (______)__________________________________

Physician's Address ____

1. Additional history not mentioned on APPLICANT'S SIDE:

____

____

____

____

____

2. Significant abnormal findings:

HEENT______________________ Pulses ______________________

Chest________________________ Extremities__________________

Heart________________________ Neurologic___________________

Abdomen_____________________ Orthopedic__________________

Other________________________

Comments: ____

____

____

3. Please provide the following, if available:

Total cholesterol ______ Blood pressure _____/______

Triglycerides ______ Resting pulse ____________

LDL ______ HDL ____________

4. I have examined the above-named individual and find no reason why she should not participate in a graded exercise test or other physical activities.

______________________________________ ____________________

Physician's Signature Date

PARTICIPANTS: PLEASE BRING THIS FORM DIRECTLY TO CHERYL LOVELADY OR MELANIE BOPP. PLEASE DO NOT HAVE YOUR PHYSICIAN'S OFFICE MAIL IT TO US. THANKS.

For further information, please contact:

Cheryl Lovelady, Ph.D., R.D.
UNCG Department of Food and Nutrition
Phone: (336) 256-0310

APPENDIX C

DATA COLLECTION FORMS

Research Study: Effect of Exercise on Bone during Lactation

First Contact Date:____ _____ __

Initial Questionnaire

Prenatal

Name ________________________ Weeks Pregnant________________

Phone Number_______________ Due Date for Infant______________

Age__________________________ Number of Children_____________
Age of children?
Breastfed? C-Sections?

Address____

Prepregnancy Weight ____lbs____kg Sedentary in 3rd trimester?_____

Current Weight_____lbs____kg Smoker?____________________

Current Height_____ft_____in Agrees to random assignment?____

Agrees to multivitamin?______

Any chronic diseases? (DM, HTN, CVD, asthma, bone/joint problems?
Medications?____

Plan to breastfeed exclusively for 1st 5 months postpartum?___________

Will you be returning to work outside the home? If so, how many hours a week?____

BMI (prepregnant):________

Comments:

Postnatal

Infant Birth Weight_____________ **Infant Birth Length_____________**

Name of Infant_________________ **Actual Birth Date for Infant______**

Gender of Infant________________ **Name of Physician______________**

Physician's Phone_______________

C-section?_________________ **Delivery/Pregnancy Complications?____**

Full term infant?___________ **Weight After Delivery?______lbs_____kg**

Singleton birth?___________ **Current Weight_______lbs______kg**

BMI____________________ **Current Height_______lbs_______kg**

How much weight did you gain during pregnancy?________________

Daily/Weekly Schedule:

Checklist:

- Initial Questionnaire Complete
- Informed Consent
- Medical Clearance Form
- Dietary recall sheets and visuals
- Breast milk sample tubes (2)
- Vitamins
- Next visit scheduled
- Forms for underwater weighing and blood draw instructions
- Directions

TREADMILL TEST: Modified Balke Protocol
Data Sheet

Name:________________________________ Date:___________________________

Resting Blood Pressure:_________________ Heart Rate:______________________

Stage	Min	% Grade	Speed	HR	RPE
1	1	0			
	2	0			
2	3	2.5			
	4	2.5			
3	5	5.0			
	6	5.0			
4	7	7.5			
	8	7.5			
5	9	10.0			
	10	10.0			
6	11	12.5			
	12	12.5			
7	13	15.0			
	14	15.0			
8	15	17.5			
	16	17.5			
9	17	20.0			
	18	20.0			
10	19	22.5			
	20	22.5			

Target HR

220
- ___ age
- ___ RHR

x 0.85

+ ___ RHR

Recovery:
2 min HR:_____________ 6 min HR:__________
4 min HR:_____________ 8 min HR:__________

Total Time of Test:_______________ Weight:___________________

Name ___________________________
Weeks Postnatal___________________
Height ________in___________cm
Weight _______lbs_____________kg
Visit # __________________________

Time since baby last nursed______
Baby weight____________________

Exercise Data – 1 RM

Name: ____ Date: _________________________

Exercise	Max Amount Lifted (lbs)	60%	70%	85%	90%
SQUATS					
BENCH PRESS					
AB PLANK	Time				
STANDING MILITARY PRESS					
STIFF LEG DEAD LIFT					
ISOMETRIC PUSH UP					
HIGH PULLS					
BENT-OVER DUMBELL ROW					
	TIME		HEIGHT		DISTANCE
WALL SIT					
ABS - CRUNCHES					

Walking Log:

** Please record the date each day you exercise aerobically, this should be 3 days/week.
** Please record what you *actually* do, even if it is different from the goal!!!
** The "Range Goal" is the amount of time you should spend in your target heart rate range. Add a 5 minute warm up and a 5 minute cool down to each session.
** Your target heart rate range is: __________

Date:	Time in Range	Total Time	Range Goal	
example				
*10/20/03_*	___*18*____	__*28*____	*18min*	
*10/22/03_*	___*22_*___	___*35*___	*21 min*	
___________	____________	__________	5 min	WEEK 1
___________	____________	__________	10 min	
___________	____________	__________	15 min	
___________	____________	__________	18min	WEEK 2
___________	____________	__________	21 min	
___________	____________	__________	24 min	
___________	____________	__________	27 min	WEEK 3
___________	____________	__________	31 min	
___________	____________	__________	34 min	
___________	____________	__________	37 min	WEEK 4
___________	____________	__________	40 min	
___________	____________	__________	43 min	
___________	____________	__________	45 min	WEEK 5
___________	____________	__________	45 min	
___________	____________	__________	45 min	

Date:	Time in Range	Total Time	Range Goal	
			45 min	WEEK 6
			45 min	
			45 min	
			45 min	WEEK 7
			45 min	
			45 min	
			45 min	WEEK 8
			45 min	
			45 min	
			45 min	WEEK 9
			45 min	
			45 min	
			45 min	WEEK 10
			45 min	
			45 min	
			45 min	WEEK 11
			45 min	
			45 min	
			45 min	WEEK 12
			45 min	
			45 min	

Date:	Time in Range	Total Time	Range Goal	
___________	____________	__________	45 min	WEEK 13
___________	____________	__________	45 min	
___________	____________	__________	45 min	
___________	____________	__________	45 min	WEEK 14
___________	____________	__________	45 min	
___________	____________	__________	45 min	
___________	____________	__________	45 min	WEEK 15
___________	____________	__________	45 min	
___________	____________	__________	45 min	
___________	____________	__________	45 min	WEEK 16
___________	____________	__________	45 min	
___________	____________	__________	45 min	

Resistance Training Week 1 – Familiarization

3 days per week – 60% - 1 set per exercise

3 second lift – hold for 0 seconds – lower for 3 seconds ** Please record date and weight lifted each day

45-60 rest between exercises

WEEK 1

Day 1		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**	1	1	1	1	1
	Number of Reps					
	Pounds Lifted					
		Stiff Leg Deadlift	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
	Number of Sets					
	Number of Reps					
	Pounds Lifted					
Day 2		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**	1	1	1	1	1
	Number of Reps					
	Pounds Lifted					
		Stiff Leg Deadlift	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
	Number of Sets					
	Number of Reps					
	Pounds Lifted					
Day 3		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**	1	1	1	1	1
	Number of Reps					
	Pounds Lifted					
		Stiff Leg Deadlift	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
	Number of Sets					
	Number of Reps					
	Pounds Lifted					

Resistance Training Weeks 2-6

Alternate days – 70% - 10-15 reps per set   3 sets per exercise

3 second lift – hold for 0 seconds – lower for 3 seconds   ** Please record date, wt. lifted, and # of reps each day

45-60 rest between exercises, straight or supersets

WEEK 2

Day 1		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 3

Day 1		Stiff Leg Deadlift	Push-ups	High Pulls	Dumbbell Row	Ab Plank
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 4

Day 1		Squats	Bench Press	Military Press	Sit-ups	Wall Sit
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 5

Day 1		Stiff Leg Deadlift	Push-ups	High Pulls	Dumbbell Row	Ab Plank
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 6

Day 1		Squats	Bench Press	Military Press	Sit-ups	Wall Sit
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

Resistance Training Weeks 7-11

Alternate days – 85% - 5-8 reps per set   4-5 sets per exercise

2 second lift – hold for 0 seconds – lower for 2 seconds   ** Please record date, wt. lifted, and # of reps each day

2 minute rest between exercises, supersets

WEEK 7

Day 1		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 8

Day 1		Squats	Bench Press	Military Press	Sit-ups	Wall Sit
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 9

Day 1		Stiff Leg Deadlift	Push-ups	High Pulls	Dumbbell Row	Ab Plank
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 10

Day 1		Squats	Bench Press	Military Press	Sit-ups	Wall Sit
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 11

Day 1		Stiff Leg Deadlift	Push-ups	High Pulls	Dumbbell Row	Ab Plank
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

Resistance Training Weeks 12-16

Alternate days – 90% - 3-5 reps per set 5 sets per exercise

3 second lift – hold for 1 second – lower as quickly as possible ** Please record date, wt. lifted, and # of reps each day

2-3 minute rest between exercises, supersets

WEEK 12

Day 1		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 13

Day 1		Stiff Leg Deadlift	Push-ups	High Pulls	Dumbbell Row	Ab Plank
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 14

Day 1		Squats	Bench Press	Military Press	Sit-ups	Wall Sit
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 15

Day 1		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

WEEK 16

Day 1		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 2		**Stiff Leg Deadlift**	**Push-ups**	**High Pulls**	**Dumbbell Row**	**Ab Plank**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					
Day 3		**Squats**	**Bench Press**	**Military Press**	**Sit-ups**	**Wall Sit**
Date:	**Number of Sets**					
	Number of Reps					
	Pounds Lifted					

CALL LOG
ID:_________________

Call date:______________________

Menses return?____________
Hormonal Birth Control? What kind?_______
Taking vitamins?_________
Exclusive breastfeeding?

Call date:______________________

Menses return?____________
Hormonal Birth Control? What kind?_______
Taking vitamins?_________
Exclusive breastfeeding?

Call date:______________________

Menses return?____________
Hormonal Birth Control? What kind?_______
Taking vitamins?_________
Exclusive breastfeeding?

Call date:______________________

Menses return?____________
Hormonal Birth Control? What kind?_______
Taking vitamins?_________
Exclusive breastfeeding?

Call date:______________________

Menses return?____________
Hormonal Birth Control? What kind?_______
Taking vitamins?_________
Exclusive breastfeeding?

APPENDIX D

INSTRUCTIONS AND INFORMATIVE FORMS

Want to GET IN SHAPE after you have your baby??

* **ARE YOU EXPECTING OR DO YOU HAVE A NEW BABY??**

* **ARE YOU INTERESTED IN PARTICIPATING IN AN *EXERCISE PROGRAM* AFTER YOU HAVE YOUR BABY??**

* **DO YOU WANT TO *GET IN SHAPE* BY IMPROVING YOUR FITNESS LEVEL AND MUSCULAR STRENGTH??**

* **DO YOU PLAN TO EXCLUSIVELY BREASTFEED FOR THE FIRST 5 MONTHS POSTPARTUM??**

YES?

Then GIVE US A CALL!

(You must be pregnant or your baby must be less than 2 weeks old)

Breastfeeding & Exercise for Healthy Infants and Postpartum Moms.

Be-Hip Mom!

Research Study

Lactation and Bone Mineral Density

UNCG Departments of Nutrition and Exercise Science

CALL: Dr. Cheryl Lovelady or Melanie Bopp at **336-256-1090**

<u>What is a DEXA Scan?</u>

Several methods will be used to determine your body fat and the distribution of your bone, muscle and fat. A Dual Energy X-Ray Absorptiometry machine (DEXA) will measure your bone density, muscle mass and body fat. This machine uses photons (energy) as it scans across your body while you are lying quietly on a padded table. The DEXA is painless, but involves exposure to low doses of x-rays. Other than minimal exposure to radiation, there are no risks associated with the DEXA scans. The amount you will receive from the DEXA scan is 1.5 millirem (whole body). The annual background radiation the average person receives each year in the United States is 360 millirem. The risk of this procedure is small. Please be aware that this radiation exposure is necessary for this research study only and is not essential for your medical care. The Wake Forest University/Baptist Medical Center's Radiation Safety Committee, a group of experts on radiation matters, has reviewed the use of radiation in this research information desired. The potential long-term risk from these radiation doses is uncertain, but these doses have never been associated with any definite adverse effects. Thus, the risk to you, if any, is estimated to be slight.

Dual X-Ray Absorptiometry (DEXA) INSTRUCTIONS

Explanation: The DEXA is an x-ray scan of your whole body that provides information about your body composition. This test shows us how much of your body is made up of muscle, fat, and bone. The amount of radiation associated with this test in minimal; in fact, the technician conducting the test does not need to leave the room or to wear special drapes or clothing for protection. This is a painless, non-invasive (no needles) test that only takes a few minutes to conduct. You will be asked to wear only clothing with no buttons, zippers, hooks, buckles or snaps. If you do not have such clothing, you may change into hospital scrubs for your DEXA. You may have this test even if you have metal in your body (such as metal plates).

Location: Located in the J. Paul Sticht Center at the Geriatric Outpatient Clinic (GOC) you will wait in the lobby until it is time for your DEXA.

Exclusions: If you are pregnant, you may not have this test.

Risks: There are no known risks associated with this procedure.

INSTRUCTIONS:

- You may eat a light breakfast the morning of this visit unless to instructed otherwise.
- You may take your medications as usual.
- Remove any items from your pockets.
- Remove all clothing containing metal or hard plastic. A hospital outfit will be provided if needed.
- Lie quietly throughout the test. The technician will remind you not to talk or move while the scanner is actually in motion (about 5 minutes).

INSTRUCTIONS FOR COLLECTION OF BREAST MILK
FOR HEALTH STATUS

In order to get an accurate assessment of your health status, we ask that you do the following:

1. Fast the night before milk, urine, and blood samples are collected. This means no food, supplements, or drink (except water) from 9:00 p.m. till after the collection of the milk and blood the following morning. **We advise frequent consumption of water the night before and during the morning to maintain adequate hydration for proper milk production!!!!!**

2. If you are currently taking supplements, we request that you not take them after 9:00 p.m. the night before and any time the morning of the blood draw and milk collection. The supplement can be taken at any time after the blood samples have been obtained.

3. Collect milk sample (4 tablespoons) the morning of the blood draw. The sample should be obtained at the first feeding after 5:00 a.m. Pour the collected into the tubes provided. Collect urine from the 1st or 2nd void of the morning, into the provided urine cup. The tubes and urine can be placed in the refrigerator until time for transport to the lab. **Please try to feed your baby a minimum of 60 (preferably 90) minutes *before* your arrival at UNCG.**

Instructions for Treadmill and Body Composition Measurements

A. Exercise Testing:

   You will need to bring (or wear) with you a pair of comfortable "workout" shorts, a T-shirt, a pair of socks and tennis shoes.

B. Bring something light to eat when you come to the lab (e.g., bagel and juice). Avoid gas-producing foods such as beans, vegetables, etc.

Your appointment is for ____________________________________

Stages of Exercise:

Week 1: Familiarization

3 days per week, 1 set of all exercises, 60% of One Repetition Max (RM). 3-0-3 tempo: 3 seconds down, hold for 0 seconds, and 3 seconds up. 45-60 seconds between each exercise. 10-15 reps of each exercise.

Weeks 2-6: Hypertrophy

Alternating days of the split routine. 70% 1RM, 10-15 reps per set, 3 sets, 3-0-3 tempo, 45-60 seconds rest. Straight set method (doing all 3 sets of one exercise and then moving onto next exercise) or superset method (doing one set of one exercise and then one set of the next until you have done all exercises for that day and then cycle back through all exercises until you finished all 3 sets for each).

Weeks 7-16: Strength

Alternating days, 85% 1RM, 5-8 reps per set, 4-5 sets, 2-0-2 tempo, 2 minutes rest between each. Superset method.

Day 1 Exercises:

Squats: Start standing up with dumbbells at side with feet shoulder width apart and slowly sit down as if sitting in a chair. Make sure knees do not go in front of ankles. Go down until butt is at a 90 degree angle with knees. Arms can be at side or above shoulders with elbows bent.

Bench Press: Can be done lying on ball or floor. On floor, lay down with back flat on floor and legs straight. Hold dumbbells in each hand and raise arms extending from shoulders, straight up. Arms should be directly over chest with elbows extending as you raise arms and elbows bending as you come back down. On ball, rest upper back on the ball in a backbend position with feet flat on the floor, shoulder width apart and extend arms from shoulders, straight up. Make sure to keep abs parallel with the floor and push hips up toward ceiling.

Standing Military Press: Stand straight up with feet shoulder width apart. Hold dumbbells in each hand and raise arms straight up toward ceiling directly from shoulders (i.e. start with elbows bent and raise arms up).

OR Push Press: Same thing as military press, but for variation add squatting down like as in the squats and as the legs become straight then push arms up in the air overhead.

Abdominal Sit-up: Lay down on floor with feet flat on the floor and knees raised. Raise upper back until elbows (or hands, depending on position) touch knees.

Easiest: Start sitting up and slowly with control lower back to the floor.

Next: Start lying down and go up to knees and back down with arms straight out towards knees.

Next: Same as above, but cross arms over chest.

Next: Same as above, but arms are behind neck with elbows bent. Make sure your arms are not pulling on neck and your stomach muscles are doing the work.

Hardest: Same as above, but do all variations on the ball. Position similar to bench press on the ball (i.e. back bend position). The farther back your back and hips are on the ball, the harder the work-out on the stomach muscles.

OR Crunches: Lay down on floor with knees bent and feet either up in the air or flat on floor. Raise upper back to a slight curl; do not come up all the way. Variations for arms are the same as abdominal sit-ups.

Wall Sits: Position back against a wall as if sitting in a chair. Make sure tops of upper leg is parallel to the floor and calf-side of lower leg is parallel to the wall. Let arms rest against back of the wall (i.e. – do not rest hands on hips or legs). Hold for as long as possible while keeping the correct technique.

Day 2 Exercises:

Stiff Leg Deadlift: Start standing up with feet about six inches apart. Keep knees slightly bent and hold dumbbells in each hand. Slowly bend over as if touching toes.

Pushups: Lay down with stomach on the floor. Feet should be about six inches apart. With hands shoulder width apart at chest/shoulder level, slowly rise up and then back down and repeat. Shoulders and elbows should be at a 90 degree angle and back should remain parallel to the floor, not arched or sagging.

Easiest: Bend knees and let knees touch the floor and back should be at an angle to the floor as you descend, but make sure back never arches. Just do the down motion and then come up to knees to get back up and then repeat the down motion again.

Next: Same position as above but do both ups and downs.

Hardest: First example, on feet (no knees), doing both ups and downs.

High Pulls: With feet shoulder width apart and knees slightly bent start with arms straight by side with dumbbells in hand and lift fists straight up so that elbows are bent and straight out and then go back down to straighten elbows. Like rowing, but pulling up towards ceiling.

Bent Over Dumbbell Row: With back straight, but slightly bent over, hold dumbbells in each hand and keep arms in 90 degree angle, while raising arms straight up, while keeping elbows bent. Feet should be shoulder width apart with knees slightly bent.

Abdominal Plank (or straight leg sit-up): Start with stomach on the floor and place elbows on the floor with arms bent. Elbows should be anywhere from under chest to further out towards the head, but inside the body. Hold body up and keep back straight, not arched or sagging. Hold position for as long as you can. Start with 5-10 seconds and work up to 30 seconds. When you can do that, move up to the next level trying to achieve one minute or more.

Easiest: Elbows under chest and on knees with legs bent and back at an angle.

Next: Extend elbows further out toward head or further out.

Next: Move up to feet only and keep legs straight.

Hardest: On feet and elbows bent on floor under head or further out.