2010-08-11

The Effects of Resistance Training on Strength and Body Composition in Postpartum Women

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A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Science

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December 2010

ABSTRACT

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The postpartum period represents a high-risk period for body weight retention and obesity. Several studies have investigated the role of aerobic exercise on postpartum weight retention and other body composition outcomes; however, there has been little attention given to resistance training in postpartum women. Thus, the purpose of this four-month randomized study was to determine the effectiveness of resistance training on strength, body composition, return to pre-pregnancy weight, and bone mineral density (BMD) in postpartum women.

Sixty postpartum women were randomly assigned to either a resistance training group or a comparison group. The resistance training group participated in a progressive resistance training program twice weekly for four months. The comparison group participated in a flexibility program twice weekly for four months. Strength changes were assessed for the upper body (bench press), lower body (leg press), and the core (abdominal curl-ups). Body composition, including BMD, was measured by dual energy x-ray absorptiometry.

Over the four-month study, the resistance training group demonstrated a 36.7% increase in bench press, a 31.1% increase in leg press, and a 222.6% increase in abdominal curl-ups ($p < 0.05$). The flexibility group improved by 7.7% for bench press, 6.6% for leg press, and by 43.0% for abdominal curl-ups ($p < 0.05$). Group*period interactions were significant for the leg press, bench press, and abdominal curl-ups ($p < 0.05$). Both groups decreased in body weight, body fat percentage, and fat tissue ($p < 0.05$). Neither group significantly changed in lean tissue, whole body BMD, and hip BMD ($p > 0.05$). Group*period interactions were not significant for any body composition outcome ($p > 0.05$). These results suggest that a twice weekly resistance training program is superior to flexibility training to increase strength; however, resistance training may not be enough to influence body composition to a greater extent than flexibility training in postpartum women. More research is warranted.

Keywords: body weight, body fat percentage, bone mineral density, weight retention, pregnancy

ACKNOWLEDGMENTS

I want to express gratitude to Landon, who has helped me through this project in every way that he could and who has given frequent words of encouragement to push me along. I also want to thank my parents who have always encouraged me to challenge myself and who taught me the value of education and perseverance.

I am very grateful to Dr. LeCheminant, who listened to me and helped me find a focus for this project. I cannot thank him enough for the countless hours he has spent to help me organize every aspect of this project down to the minuscule details and for genuinely caring about my success. I also want to thank Dr. Tucker and Dr. Bailey, whose expertise provided valuable insight to make this project better. Finally, I am thankful to Tiffany Hinman, Nathan Earl, and all the research assistants who helped accomplish the work this project required.

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Introduction

The prevalence of obesity is escalating in the United States and women have a greater prevalence of obesity than men (7). As of 2008, 35.5% of adult women in the United States were obese, defined by a Body Mass Index (BMI) of 30 kg/m^2 or greater (7). Many years of research has linked obesity to several chronic diseases, such as coronary heart disease, type 2 diabetes, hypertension, hypercholesterolemia, and stroke (19,28). Due to the potential adverse outcomes related to obesity, weight management interventions are often initiated by health professionals; however, current interventions have failed to attenuate the obesity epidemic.

In recent research, attention has been given to high-risk periods for weight gain and obesity in women, such as pregnancy and post-pregnancy (postpartum). Regarding the postpartum period, excess body weight retained above pre-pregnancy weight six months after delivery has been shown to be associated with long-term weight retention and increased risk for obesity (23). Postpartum weight retention is variable among women, but the average range is -0.27 kg to 3.0 kg (9). However, some women retain as much as 17.7 kg (9). Due to the increased likelihood of obesity and associated health risks that may accompany postpartum weight retention, postpartum represents a critical period for weight management interventions. In addition, motivation to lose weight may be increased during the postpartum period, thereby providing additional rationale for interventions during this time.

Furthermore, research shows that low bone mineral density can be attributed to physical inactivity and sedentary living (27). Because women are typically less active during pregnancy and the postpartum period, up to 5% bone mineral loss may occur (13).

Aerobic exercise and/or diet interventions are commonly used among researchers to encourage return to pre-pregnancy weight, with mixed results (17,21). Most studies have not incorporated resistance training exercise. Although recent physical activity recommendations from the American College of Sports Medicine (ACSM) and American Heart Association include regular resistance training (11), research interventions investigating resistance training are virtually nonexistent in postpartum women.

Furthermore, known benefits associated with resistance training in non-postpartum women exist that may also positively affect weight management in postpartum women. The following five outcomes may be applicable to postpartum women: 1) resistance training may increase strength outcomes or increase the speed of returning to pre-pregnancy strength; 2) resistance training may improve body composition outcomes, such as decreasing abdominal obesity and increasing muscle mass (6,24); 3) resistance training may increase total daily energy expenditure by increasing muscle mass (14); 4) resistance training increases energy expenditure during the training session (10,22); and 5) resistance training may result in increases in bone mineral density (27).

The extent that resistance training influences these outcomes during the postpartum period is currently unknown as only one recent study has incorporated resistance training, combined with aerobic training, in postpartum women (16). The present study attempted to fill this gap in the scientific literature. Therefore, the purpose of this four-month randomized study was to determine the effect of resistance training on strength, body composition, return to pre-pregnancy weight, and bone mineral density (BMD) in postpartum women. The hypotheses for this study were that the resistance training group would have greater increases in strength, lean mass, and bone mineral density, as well as have greater decreases in weight, body fat percentage, and fat mass when compared to the flexibility group.

Methods

Participants

Sixty postpartum women were recruited to participate in this study. Upon recruiting, the participants were required to be at least six weeks but no more than eight months postpartum. In addition, they were required to be at least five pounds above their pre-pregnancy weight and non-smokers. A Physical Activity Readiness Questionnaire was used to assess participant health and exercise readiness (1). Participants were excluded from the study if they were unable to perform moderate intensity exercise, engaged in resistance or flexibility training two or more times per week for the previous six months, or who were participating in any commercial diet. Each participant was also required to obtain physician consent indicating she was healthy enough to participate in the study.

Prior to the recruitment of participants, this study was approved by the Institutional Review Board at Brigham Young University for the use of human participants. The participants were recruited through fliers and posters distributed throughout the university campus, obstetric offices, and by word of mouth. All participants provided informed consent before participating in the study.

Intervention

For the purpose of this study, 60 women were randomly assigned to either the intervention group or the comparison group. The intervention group participated in a progressive resistance training program that included nine exercises, completed twice weekly, for four months. The exercises targeted all major muscle groups and included: leg press, leg curl, leg extension, bench press, shoulder press, lat pull-down, biceps curl, seated row, and abdominal crunches.

For the first month, all resistance training sessions were supervised. Thereafter, at least one session per week was supervised and the other verified that it was completed. The first month consisted of one set of each exercise using a resistance that the participant could perform between eight and twelve repetitions. Once the participant could perform 12 or more repetitions, the resistance was increased by one machine increment at the following training session. For the second month, the participants progressed to two sets for each exercise. The women performed 10 repetitions of each exercise on the first set. For the second set, the same weight was used as the first set, only the participants completed as many repetitions as possible to fatigue. Once they could perform12 or more repetitions on the second set for a given exercise, the amount of resistance was increased at the following training session by one machine increment for each set. For months three and four, the participants progressed to three sets. The resistance was set at a weight where the participant could complete 10 repetitions for the first and second sets. On the third set, they completed as many repetitions as possible. The weight increased by one weight machine increment when the participant was able to perform at least12 repetitions on the third set of a given exercise.

When participants needed to miss a session for being out of town, they were encouraged to complete push-ups, lunges, and crunches to fatigue while away. The number of sets was determined by the month of the study they were in at the time. During the first month, they completed one set of each exercise, during the second month two sets of each exercise, and three sets during the third and fourth months. However, when the participants did these alternative sessions, it was not counted as a completed session. When minor pain occurred during a specific exercise, participants were advised to lower the amount of resistance to see if that alleviated the pain. If the pain persisted, the participant was advised not to perform that exercise until the injury healed and then to slowly resume that exercise. If the pain or injury was severe enough, participants withdrew from the study.

Flexibility training was chosen for the comparison group as it likely did not influence the major outcomes of the study, but kept the participants engaged in the study. The comparison group participated in a four-month flexibility program based on the recommendations of the ACSM (1). These guidelines prescribed for the flexibility participants included participating in stretching exercises on two nonconsecutive days per week. Each stretching session included four sets per muscle group and each stretch was held between 10 and 30 seconds. Flexibility exercises emphasized the following major muscle groups: low back and hamstrings, quadriceps, calves, neck, arms, and torso. The comparison group was invited to attend a group stretching session once each week and asked to complete the second session on their own. The comparison group was asked not to participate in resistance training for the duration of the study.

Measurements and procedures

To analyze the main outcomes of this study, the participants were assessed at baseline, two months, and four months. Each testing period consisted of two visits. On the first testing visit, flexibility was assessed and the participants practiced the strength assessments. At the second visit, all participants were assessed for strength, anthropometric variables, and body composition.

Flexibility

Flexibility was assessed for the low back and hamstrings using a V sit-and-reach test and a standardized sit-and-reach test at baseline, two months, and four months. These tests have been found to be moderately to strongly related to hamstring flexibility in adults, indicated by correlation coefficient ranges of 0.39 to 0.89, and are often used as valid measures of low back and hamstring flexibility (12). Prior to testing, the participants walked for 5 minutes followed by mild stretching exercises. Subsequently, the V sit-and-reach test was administered by placing a 12-inch long piece of tape on the floor, perpendicular to the 15-inch mark on a yardstick secured to the ground (29). The participants then straddled the yardstick with their heels at the 15-inch mark, 12 inches apart, with their toes pointed upward, and legs and knees extended. The participants then leaned forward with arms extended and reached as far as they could and held the stretch for three seconds. The average of three attempts was used for data purposes.

For the standard sit-and-reach test, a standard box where the zero mark is on the edge of the box was used as indicated by the Canadian Society for Exercise Physiology (CSEP) (3). Each participant sat with her legs together and extended, and the soles of her feet against the edge of the box. She then reached forward with arms extended and knees straight along the top of the box and reached as far as she could and held that position for three seconds. The average of three attempts was used for data purposes.

Strength

Strength was assessed for each participant at baseline, two months, and four months for the following three exercises; leg press (lower body), bench press (upper body), and abdominal curl-ups. For the leg press, the subject sat in the machine so the knees were flexed to 90 degrees.

The angle was verified by a goiniometer at baseline. The seat position that was used that corresponded with the 90 degree angle was recorded for each subject at baseline and used at each subsequent data collection period for consistency. For the seated bench press, the participants sat in the machine so that the handles were at chest level and as close to the chest as possible. The seat position that was used to achieve the proper form for the bench press were recorded for each subject at baseline and used at each subsequent data collection period.

To reduce the chance of injury sometimes associated with maximal strength testing, strength was determined from the leg press and bench press using resistance in which the subject could perform no more than eight repetitions. Prior to strength testing, the participants completed a warm-up of low-intensity aerobic exercise (walking) for five minutes, brief stretching, and 10-20 sub-maximal repetitions for each test exercise. For both the leg press and bench press strength tests, an initial weight was selected that was within perceived capacity of the subject. The weight was progressively increased by no less than five pounds until no more than eight repetitions could be completed at a given weight. Between each weight increase, the participants rested for at least three minutes. Their 1 repetition maximum (1RM) was then estimated using the following equation (2).

$$1\text{RM} = \text{weight lifted (lb)} / [1.0278 - (\text{reps to fatigue} \times 0.0278)]$$

The equation developed by Bryzicki has been found to be a valid method to estimate 1RM (15,18). High correlations have been found for using this prediction equation to estimate 1RM when compared to achieved 1RM, particularly for the bench press, which had a correlation coefficient of 0.993 in a study of men and women (15).

Abdominal strength was assessed by using a protocol adapted from the ACSM partial curl-up test (1). This was accomplished with subjects lying in the supine position with knees flexed at a 90 degree angle, feet flat on the floor, and arms at the sides and extended downward with fingers touching a piece of masking tape on the mat. A second piece of tape was placed 10 cm beyond the first piece. A metronome was set to 40 beats per minute. Each participant then slowly lifted her shoulder blades and torso off the mat until her fingers reached the second piece of tape. Rather than having the participants stop after one minute, per traditional partial curl-up test protocol, they were scored based on the number of curl-ups they could complete while staying on the cadence and keeping the correct form to fatigue.

Anthropometric and body composition outcomes

Body composition and anthropometric measurements were assessed at baseline, two months, and four months. Body weight was obtained in standardized clothing, a bathing suit, using a digital scale accurate to the nearest ± 0.1 kg (Life Measurement, Inc., Concord, CA). Height was obtained using a wall mounted stadiometer. BMI was calculated using height and weight. Waist and hip measurements were obtained according to the ACSM protocol (1). Waist measurements were taken as the subject stood with arms at the side, feet together, and abdomen relaxed. A horizontal measure was taken at the narrowest part of the torso, which is generally above the umbilicus and below the xiphoid process (1). Hip measurements were taken with the subject standing upright with feet together. A horizontal measurement was taken at the largest circumference of the buttocks (1). Each measurement was taken using a spring loaded measuring tape. At least three measurements, within 2 cm, were taken to ensure accuracy. The average of the three measurements was used for data purposes.

Lean mass, fat mass, body fat percentage, whole bone mineral density (BMD), and hip BMD were assessed by dual energy absortiometery (DXA) (Hologic Inc, Bedford, Massachusetts). DXA is widely accepted as a valid and reliable method of measurement for body composition (8,26). All body composition measurements were performed on participants after abstaining from food, caffeine, and exercise for at least three hours.

Statistics

This study was originally powered based upon likely lean tissue changes in non-postpartum women. However, as there were no resistance training studies for comparison, the power analysis was somewhat speculative. Nevertheless, the power analysis revealed that 60 participants were needed to achieve ~80% power. PC-SAS (SAS Institute, Inc. Cary, NC) was used to randomize the participants into groups and to analyze all descriptive and outcome data (body composition, anthropometrics, strength, and bone mineral density). Independent t-tests were used to determine differences in descriptive data between groups at baseline. Mixed effects models were utilized to determine differences within each group over the duration of the study and to test for a group*period interaction. For all analyses, the baseline variable was added to the model as a control variable. Additional analyses were conducted with statistical control for number of children, weight gain during pregnancy, time postpartum upon initiating the study, and weight retained postpartum and are included in the results section. As this study was primarily an efficacy study, analysis for completers only are described in the results section.

Results

A description of the participants at baseline, including demographics and postpartum characteristics, are found in Table 1. Height was the only variable that was significantly different between the resistance training and flexibility groups at baseline. On average, the participants were 26.4 ± 4.7 years old, predominantly white (90%), and 97% were breastfeeding. The average participant was 3.8 months postpartum (range: six weeks to 7.5 months) and tended to be overweight (26.6 ± 3.9 kg/m^2).

Of the 60 participants who initiated the study, 43 completed all aspects of the study. Descriptive baseline statistics are found for the 43 completers in Table 2. Height and BMI were significantly different between the resistance training and flexibility groups at baseline for those who completed the entire study. Table 3 indicates reasons for dropout, which included; becoming pregnant, injury, loss of interest, time constraints, moving out of the area, dropping at the beginning of the study after being randomized to a group, and not returning calls or showing up for testing appointments. Comparison of participants who completed the study ($n = 43$) versus those who did not ($n = 17$) revealed that body weight, lean tissue, hip BMD, bench press, and weight retained postpartum were significantly different ($p < 0.05$). Those who did not complete the study had higher means for body weight, lean tissue, hip BMD, bench press, and weight retained postpartum than those who completed the study ($p < 0.05$). For the flexibility group, ~84% of stretching sessions were reported to be completed. For the resistance training group, ~94% of sessions were completed.

The flexibility group improved for the V sit-and-reach on average 2.9 centimeters, a 6.3% increase from baseline to the four-month follow-up. Similarly, the resistance training group increased in the V sit-and-reach by 2.6 centimeters, or a 5.7% increase. There was not a significant group*period interaction for the V sit-and-reach ($p > 0.05$). For the standard sit-and-reach, the flexibility group increased ~12.4%, or 3.9 centimeters ($F = 14.52$, $p < 0.001$). The resistance training group improved in the standard sit-and-reach by 4.0 centimeters, or a 13.3% increase ($F = 9.70$, $p < 0.001$). There was not a group*period interaction for the standard sit-and-reach test ($p = 0.096$).

Strength outcomes are reported in Table 4. For the leg press, the flexibility group increased their estimated 1RM for leg strength by 6.1 kg, a 6.6% increase ($F = 5.30$, $p = 0.009$). In the resistance training group, the estimated 1RM for the leg press increased by an average of 25 kg, a 31.1% increase ($F = 31.89$, $p < 0.001$). There was a significant group*period interaction for the leg press, indicating that the resistance training group saw significantly greater strength gains than the flexibility group ($F = 8.74$, $p = 0.005$).

For the bench press, estimated 1RM increased for the flexibility group by an average of 2.2 kg, a 7.7% increase ($F = 8.79$, $p = 0.001$) and for the resistance training group an average increase of 9.9 kg, or 37% ($F = 58.15$, $p < 0.001$). A group*period interaction was significant for the bench press in favor of the resistance training group ($F = 31.39$, $p < 0.001$).

The flexibility group improved their abdominal strength by performing 23.5 more curl-ups at four months than baseline ($F = 6.12$, $p = 0.005$). The resistance training group was able to perform an average of 82.8 additional curl-ups after four months of resistance training ($F = 16.07$, $p < 0.001$). A group*period interaction was significant for the abdominal curl-ups, indicating that the resistance training group had greater abdominal strength gains than the flexibility group ($F = 8.10$, $p = 0.007$).

Table 5 shows the results for body composition at baseline, two-month, and four-month data collection periods for the 43 completers. Among the flexibility group, body weight decreased by an average of 3% ($F = 7.85$, $p = 0.001$). For the resistance training group, body weight decreased by 4.5% ($F = 23.70$, $p < 0.001$). A group*period interaction was not significant for body weight ($F = 2.78$, $p = 0.103$).

Waist circumference decreased by about 3.3% among the flexibility group, or 2.8 cm ($F = 7.82$, $p = 0.001$). Similarly, waist circumference decreased by about 2.8%, or 2.2 cm on average among the resistance training group ($F = 8.55$, $p = 0.001$). Differences between the flexibility and resistance training groups over time was not significant ($F = 0.35$, $p = 0.557$).

Body fat percentage decreased an average of 2.1 percentage points, a 5.6% decrease, among the flexibility group from baseline to four months ($F = 9.85$, $p = 0.005$). For the resistance training group, body fat percentage decreased by 2.6 percentage points, a 7.5% decrease ($F = 35.38$, $p < 0.001$). A group*period interaction was not significant for body fat percentage ($F = 0.53$, $p = 0.472$).

Fat tissue decreased by 7.7% among the flexibility group ($F = 12.88$, $p = 0.002$). Significant decreases in fat tissue were also observed in the resistance training group with a decrease of 11.2% ($F = 38.41$, $p < 0.001$). Group*period interactions between the flexibility and resistance training groups was not significant for fat tissue ($F = 0.63$, $p = 0.433$).

Lean tissue decreased by 0.2% in the flexibility group, however, the decrease was not statistically significant ($F = 0.04$, $p = 0.837$). On average, lean tissue increased by 0.1% in the resistance training group over the four-month period, however, the increase was not significant ($F = 0.02$, $p = 0.886$). In addition, the difference between the flexibility and resistance training groups over time was not significant ($F = 0.06$, $p = 0.807$).

Bone mineral density (BMD) was also assessed as part of body composition and the results are shown in Table 5. Whole body BMD changes were not significant within the flexibility or resistance training groups ($p > 0.05$). A group*period interaction was not significant for whole body BMD ($F = 3.45$, $p = 0.07$). For hip BMD, neither the flexibility group nor resistance training group had significant changes ($p > 0.05$). Furthermore, a group*period interaction was not significant for hip BMD ($F = 0.14$, $p = 0.707$).

When controlling for number of children, weight gain during pregnancy, time postpartum upon initiating the study, and weight retained postpartum, individually or combined, there were no significant changes in group*period interactions for any body composition variable reported in Table 5.

Discussion

The major hypotheses for this study were that the resistance training group would have greater increases in strength, lean mass, and bone mineral density, as well as have greater decreases in weight, body fat percentage, and fat mass when compared to the flexibility group. The results indicate that the resistance training group produced superior strength gains compared to the flexibility group; however, this study did not find significant differences for any aspect of body composition assessed when compared to the flexibility group. Therefore, the initial hypotheses regarding body composition were not supported.

Evidence from this study suggests that a regular resistance training program produces significant strength gains in postpartum women. Only one other study has evaluated the effect of resistance training in postpartum women (16). In the current study, the estimated 1RM for leg press increased by 31.1% while the estimated 1RM for bench press increased by 36.7%. Lovelady et al. did not test for the leg press, but did have a 46% increase for the squat and 63% increase for the bench press (16). Although Lovelady et al. reported greater increases in strength from baseline to follow-up, their intervention group performed resistance training three times a week for 16 weeks whereas the present study trained only twice per week for approximately the same time period. In addition, their intervention group had a much lower baseline strength compared to the present study and there was less than half the sample size (n = 20) of the present study (16). Thus, considering these study design differences, the strength change differences between the two studies were not surprising.

Nevertheless, the present study is consistent with studies performed among premenopausal and non-postpartum women for strength outcomes. For example, similar results were seen in a study by Chilibeck et al., where the women had a 23% increase for the leg press and 33% for the bench press by participating in a twice-weekly resistance training program for 20 weeks (5). Since muscle strength and endurance are important components of fitness and are more recently emphasized in ACSM recommendations, this study reinforces the effectiveness of a regular resistance training program in improving strength outcomes among women. More importantly this study highlights the effectiveness of resistance training in postpartum women to improve strength.

The current resistance training study did not find significant increases in lean mass as seen in other studies targeting premenopausal and non-postpartum women. Other studies in non-postpartum women have found increases in lean body mass of 0.89-2.2 kg, whereas the current study found an average increase of only 0.05 kg, which was not a statistically significant change from baseline and was not different than the comparison group (24,6). However, unlike the present study, Lovelady et al. recently found that lean tissue decreased but the loss was significantly attenuated with resistance training in the postpartum women studied compared to the controls (16). The difference in results may be attributed to the fact that their study participated in resistance training three times each week. The three days per week program was a greater stimulus and may have helped retain more lean tissue. Since only two known studies have investigated the effect of resistance training on lean tissue in postpartum women (16, and the present study), it is difficult to make solid conclusions. More research is warranted.

The results from the present study for lean tissue were unexpected, but are likely attributed to the fact that both groups lost a significant amount of body weight over the four months. With weight loss, it is common to have lean tissue losses or fewer gains in lean body mass, even with regular resistance training (25). As all women recruited for the study were above their pre-pregnancy weight, it was not surprising that all participants lost weight and with it, lean tissue.

The current study found that resistance training produced similar decreases in body fat percentage as other studies in both postpartum and non-postpartum women (24,6,16). Although the decreases in body fat percentage in the resistance training group were similar to other studies, they were not significantly different in comparison to the flexibility group in the present study. This was likely due to the fact that postpartum women tend to naturally lose excess body weight and body fat. The resistance training may not have been enough of a stimulus to further improve body fat loss compared to flexibility training.

The effects of resistance training on bone mineral density in premenopausal women have been mixed in recent research. The current study did not find a group*period interaction for whole body BMD or hip BMD. This finding was similar to Lovelady et al.; however, Lovelady et al. found that there was less loss in lumbar spine BMD in the resistance training group compared to the control group (16). Unfortunately, lumbar spine BMD was not measured in the present study and thus comparisons cannot be made for this variable. These results were unexpected; nevertheless, it is possible that four months may not be an adequate time to see significant increases in whole body or hip BMD as a result of a resistance training program.

Another noteworthy result from the present study was that the resistance training group improved in their flexibility as much as the flexibility group. This finding provides supporting evidence to the idea that performing resistance training exercises through a full range of motion does not hinder flexibility (20). In addition, the flexibility group stretched only twice weekly, which may not be a sufficient stimulus to significantly improve flexibility. Also, the present study only assessed low back/hamstring flexibility. It may be that the results of other, unmeasured assessments of flexibility were significantly greater in the flexibility group.

The most notable limitation of this study was a lack of power resulting from the modest sample size. Recruitment of subjects for this study was more difficult than expected because of the inclusion and exclusion criteria; particularly to find available participants six weeks to eight months postpartum. As a result, the study started with 60 participants and with dropouts, only 43 participants completed all aspects of the study. Therefore, power decreased, which may have influenced the results.

Another possible limitation to the present study was that the participants may not be representative of the general postpartum population. As participation was voluntary for the current study, it is possible that the participants had an interest in exercising and a desire to be part of an exercise study. In contrast, the general postpartum population may not have the same interest for exercise. Furthermore, the participants were predominantly white and 97% were breastfeeding upon initiation of the study. According to the Center for Disease Control and Prevention (CDC), 33.1% of U.S. mothers exclusively breastfed three months postpartum in 2009 (4). At six months postpartum, 43.4% of U.S. mothers did some breastfeeding, and by 12 months postpartum, only 22.7% of U.S. mothers did some breastfeeding (4). In comparison to national averages, the current study had more breastfeeding mothers. Therefore, the results from this study do not generalize well to the normal postpartum population.

In the present study, 33% of the resistance training group participants dropped out of the study. However, only two f these participants stopped because they either did not like the resistance training program or did not tell us why they were discontinuing. In addition, about 94% of the resistance training sessions were completed by the 20 remaining resistance training participants. This may indicate that a twice-weekly, progressive resistance training program is feasible for postpartum women with a baby and sometimes other young children. However, anecdotal evidence suggested that progressing from two to three sets was more difficult for the participants. Therefore, a program consisting of twice-weekly resistance training with one to two sets per exercise may be more feasible for postpartum women for the long-term. Since the current study does not have any hard data to support this suggestion, more research is warranted. Future research ought to investigate what type of a resistance training program is both feasible for the long-term and that also yields significant strength and body composition improvements for postpartum women.

Conclusion

In conclusion, participation in a progressive resistance training program for four months produces significant strength gains compared to flexibility training in postpartum women. On the other hand, resistance training twice per week may not be enough to reduce body fat, increase lean mass, or increase BMD compared to flexibility training in postpartum women. Since this is one of the first studies to investigate the influence of resistance training on the components of body composition among postpartum women, future research is warranted to confirm or refute the findings of the current study.

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Table 1. Demographics/Baseline Characteristics for All Participants

	Combined (n = 60)	**FG (n = 30)**	**RT (n = 30)**	**T**	**p**
Variables					
Age (yrs)	26.4 ± 4.7	25.9 ± 4.4	26.9 ± 5.1	0.82	0.417
Height (cm)	165.4 ± 6.6	163.1 ± 7.3	167.7 ± 5.0	2.83	0.006
Weight (kg)	72.7 ± 12.2	72.0 ± 13.0	73.3 ± 11.4	0.40	0.687
BMI (kg/m^2)	26.6 ± 3.9	27.0 ± 4.1	26.1 ± 3.7	0.97	0.335
Body Fat (%)	36.3 ± 5.7	37.0 ± 6.1	35.7 ± 5.4	0.83	0.411
Postpartum					
Months Postpartum	3.8 ± 1.7	3.9 ± 1.8	3.6 ± 1.6	0.36	0.721
Pregnancy Weight Gain (kg)	16.4 ± 4.9	16.6 ± 4.5	16.2 ± 5.3	0.04	0.967
Weight Retained (kg)	6.5 ± 3.8	6.5 ± 4.0	6.5 ± 3.7	0.04	0.687
Number of Children	2.0 ± 1.2	1.8 ± 0.9	2.1 ± 1.4	0.77	0.445

Values are means ± SD.

FG: Flexibility Group

RT: Resistance Training Group

Table 2. Demographics/Baseline Characteristics for Completers Only.

	FG (n = 23)	**RT (n = 20)**	**T**	**p**
Variables				
Age (yrs)	26.0 ± 4.0	26.4 ± 4.1	0.36	0.722
Height (cm)	162.8 ± 7.6	167.6 ± 5.1	2.40	0.021
Weight (kg)	72.1 ± 13.2	69.1 ± 8.2	0.86	0.395
BMI (kg/m^2)	27.1 ± 3.9	24.6 ± 2.9	2.36	0.023
Body Fat (%)	37.2 ± 5.9	34.5 ± 5.1	1.33	0.124
Postpartum				
Months Postpartum	3.6 ± 1.6	3.4 ± 1.4	0.60	0.557
Pregnancy Weight Gain (kg)	15.6 ± 2.9	16.3 ± 5.0	0.59	0.560
Weight Retained (kg)	5.8 ± 3.2	5.4 ± 2.5	0.40	0.694
Number of Children	1.9 ± 0.9	2.0 ± 0.9	0.30	0.763

Values are means ± SD.

FG: Flexibility Group

RT: Resistance Training Group

Table 3. Reasons for Dropout.

Reason for Dropout	Number of Dropouts
Became Pregnant	3
Shoulder Injury	2
Knee Injury	1
Loss of Interest	2
Time Constraints	2
Moved	2
Dropped at beginning after being randomized	2
Did not return calls or did not show up for testing	3
Total	**17**

Table 4. Strength Outcomes for Completers Only.

	Flexibility Group (n = 23)				Resistance Training Group (n = 20)				F	p†
Variables	Baseline	2-Month	4-Month	% Change	Baseline	2-Month	4-Month	% Change		
Leg Press (kg)	91.9 ± 23.0	94.1 ± 22.2	98.0 ± 27.6*	6.6	80.4 ± 15.2	95.4 ± 17.3	105.4 ± 18.3*	31.1	8.74	0.005
Bench Press (kg)	28.6 ± 5.4	30.7 ± 6.2	30.8 ± 6.0*	7.7	27.0 ± 6.2	31.7 ± 6.9	36.9 ± 9.0*	36.7	31.39	< 0.001
Curl-ups (#)	54.7 ± 44.6	65.5 ± 52.0	78.2 ± 60.2*	43.0	37.2 ± 21.1	68.3 ± 50.3	120.0 ± 87.9*	222.6	8.10	0.007

Values are means ± SD.

p† = Group*period interaction with control of the baseline variable (p < 0.05).

*Within group changes (p < 0.05).

Table 5. Body Composition Outcomes for Completers Only.

	Flexibility Group (n = 23)				**Resistance Training Group (n = 20)**				**F**	**p†**
Variables	Base	2-Month	4-Month	% Change	Base	2-Month	4-Month	% Change		
Weight (kg)	72.1 ± 13.2	70.6 ± 13.6	69.9 ± 13.5*	-3.1	69.1 ± 8.2	67.8 ± 8.2	66.2 ± 8.0*	-4.2	2.78	0.103
BMI (kg/m^2)	27.1 ± 3.9	26.6 ± 4.2	26.3 ± 4.2*	-3.0	24.6 ± 2.9	24.1 ± 3.0	23.6 ± 3.0*	-4.1	2.41	0.128
Waist (cm)	84.6 ± 9.1	83.1 ± 9.1	81.8 ± 8.4*	-3.3	80.5 ± 6.3	79.1 ± 6.5	78.3 ± 6.5*	-2.7	0.35	0.557
Hips (cm)	107.0 ± 9.4	105.7 ± 10.0	104.5 ± 9.6	-2.3	103.9 ± 6.8	102.4 ± 6.1	101.2 ± 6.4	-2.6	0.00	0.986
Body Fat (%)	37.2 ± 5.9	ND	35.1 ± 7.2*	-5.6	34.5 ± 5.1	ND	31.9 ± 5.2*	-7.5	0.53	0.472
Fat Mass (g)	25,197.6 ± 7,677.8	ND	23,254.1 ± 8,055.3*	-7.7	22,228.3 ± 5,578.6	ND	19,734.9 ± 5,276.0*	-11.2	0.63	0.433
Lean Mass (g)	39,810.1 ± 6,044.6	ND	39,713.8 ± 6,360.7	-0.2	39,688.3 ± 3,802.2	ND	39,731.9 ± 3,882.1	0.1	0.06	0.807
Whole BMD	1.1 ± 0.1	ND	1.1 ± 0.1	0.0	1.1 ± 0.1	ND	1.1 ± 0.1	0.0	3.45	0.070
Hip BMD	0.9 ± 0.1	ND	0.9 ± 0.1	0.0	0.9 ± 0.1	ND	0.9 ± 0.1	0.0	0.14	0.707

Values are means ± SD. ND = No data.

p† = Group*period interaction with control of the baseline variable ($p < 0.05$).

*Within group changes ($p < 0.05$).

Appendix A

Prospectus

Chapter 1

Introduction

The prevalence of obesity is continuing to escalate in the United States and women have a greater prevalence of obesity than men (26). As of 2006, 35.3% of adult women in the United States are obese, defined by a Body Mass Index (BMI) of 30 kg/m^2 or greater (26). Much research has linked obesity to several chronic diseases such as coronary heart disease, type 2 diabetes, hypertension, hypercholesterolemia, and stroke. Because of the possible adverse outcomes related to obesity, weight management interventions are often initiated by health professionals; however, current interventions have failed to attenuate the obesity epidemic.

Many well-documented factors contribute to weight gain and obesity. In recent research, attention has been given to high-risk periods for weight gain and weight retention in women, such as pregnancy and postpregnancy. Specifically, prolonged weight retention, > six months after delivery (postpartum), has been shown to be associated with long-term risk for weight retention and obesity (31). Postpartum weight retention is variable among women, but the average range is -0.27 kg to 3.0 kg (11). However, some women retain as much as 17.7 kg (11). Due to the increased likelihood of obesity and associated health risks that may accompany postpartum weight retention, postpartum represents a critical period for weight management interventions targeting women. In addition, motivation to lose weight may be increased during the postpartum period, thereby providing additional rationale for interventions during the postpartum period. Furthermore, research shows that low bone mineral density can be attributed to physical inactivity and sedentary living (41). Because women are typically less active during pregnancy and the postpartum period, bone mineral loss may occur (19). Karlsson et al. suggest that up to 5% bone loss may occur during pregnancy and lactation.

Some investigators have used aerobic exercise and/or diet interventions to encourage postpartum weight loss, with mixed results, but most have not incorporated resistance training exercise. Although recent physical activity recommendations from the American College of Sports Medicine (ACSM) and American Heart Association include regular resistance training, interventions including resistance training are virtually nonexistent in postpartum women (17). Furthermore, there are known benefits associated with resistance training that may positively affect weight management in postpartum women. The following five examples are applicable to postpartum women: 1) resistance training may increase strength outcomes or increase the speed of returning to prepregnancy strength; 2) resistance training may improve body composition outcomes by decreasing abdominal obesity and increasing muscle mass (7); 3) resistance training has been shown to increase energy expenditure by increasing muscle mass (22); 4) resistance training increases energy expenditure during the training session (14,29); and 5) resistance training is associated with improvements in bone mineral density in women (41). However, the extent that resistance training influences these outcomes during the postpartum period is currently unknown. As there are virtually no studies that have incorporated resistance training as a weight management strategy in a postpartum population, this study will attempt to fill this gap in the scientific literature.

Statement of the Problem

Therefore, the purpose of this 4-month randomized study is to determine the effectiveness of resistance training on strength, body composition, return to prepregnancy weight, and bone mineral density in postpartum women. A comparison group will include postpartum women who will not participate in resistance training, but will participate in a flexibility program. Flexibility was chosen as a comparison group as a strategy to retain participants because it is not typically associated with influencing changes in strength, body composition, or bone mineral density. It is hypothesized that the resistance training group will have greater decreases in body fat percentage and greater strength, lean body mass, and bone mineral gains than the flexibility group at the end of the four-month intervention.

Delimitations

Healthy postpartum women will be recruited for this study. Participants will be determined as healthy based on health history, Physical Activity Readiness Questionnaire (PAR-Q), and consent from their physicians. They will be nonsmoking women and must be at least six weeks postpartum, but no more than eight months postpartum at the beginning of the study. Furthermore, the women must be at least 5 lbs. above their prepregnancy weight at the beginning of the study. They will not have performed resistance training or flexibility training two or more times per week for the previous six months. They will not be participating in a commercial weight loss program and not planning to become pregnant or leave the area in the next year. They will be able to break away from family responsibilities twice weekly for approximately one hour to engage in resistance training. They will be willing to be randomized to either group (resistance or flexibility).

Limitations

Not all training sessions will be supervised. Unsupervised sessions will be self reported and will depend on the honesty of the participants. However, most sessions will be supervised, which is a significant strength of the study.

Comparison (flexibility) group members may participate in resistance training even though they will be asked not to.

Because the study requires women to be between six weeks and eight months postpartum, they will not all begin the study at the same time postpartum. This may affect the women to respond differently to the treatments.

Number of children is not part of the inclusion/exclusion criteria. Therefore the women will likely have different numbers of children, which may affect the results associated with the treatments.

Results will be based on a sample of predominantly White, religious, postpartum women and may not be representative of other postpartum women.

Assumptions

The subjects will participate in prescribed exercise sessions for the duration of the study.

The flexibility group will not participate in resistance training through the four months of the study.

The subjects will follow proper protocol for testing, including abstaining from food, drink, exercise, and caffeine three hours prior to having their weight and body composition measured.

Operational Definitions

Postpartum - Up to one year after the time of child birth.

Resistance training - A method of exercising that uses resistance, which can include body weight, weight machines, and free weights.

1 repetition maximum (1 RM) - The maximum amount of weight a person can lift one time for a given exercise.

Repetition - The number of times the exercise is performed.

Set - A given number of continuous repetitions.

Body Mass Index (BMI) - A ratio of the weight of an individual measured in kilograms divided by height that is squared in meters (kg/m^2).

Obesity - A serious and common health problem characterized by a BMI ≥ 30 kg/m^2.

Physical Activity Readiness Questionnaire (PAR-Q) - A questionnaire that serves to alert those with elevated risk to consult their physician prior to participation in physical activity.

Bone Mineral Density - A measure of bone density to determine the strength of the bones by assessing the amount of bone matter per cubic centimeter.

Dual Energy X-ray Absorpiometry (DXA) - An instrument used to measure bone mineral density and body composition in humans.

Chapter 2

Review of the Literature

The prevalence of obesity has continued to escalate in the United States, with women having greater prevalence when compared to men. As of 2006, 35.3% of adult women in the United States are obese, defined by a Body Mass Index (BMI) of 30 kg/m^2 or greater (26). With the rise in obesity rates, much research has shown that this disease can be a risk factor for several other chronic diseases such as coronary heart disease, type 2 diabetes, hypertension, hypercholesterolemia, and stroke. Research has also found a correlation between obesity and some cancers, including breast, colorectal, and endometrial (5). Because of the many possible adverse outcomes of obesity, weight management interventions are often initiated by health promotion professionals. However, current interventions have failed to attenuate the obesity epidemic.

Many factors contribute to the onset of weight retention among individuals. In women specifically, weight retention after pregnancy (postpartum) can often lead to weight gain and obesity (31). Postpartum weight retention is variable among women, but the average range is -0.27 kg to 3.0 kg. However, some women retain as much as 17.7 kg (11). Due to the health risks that may accompany postpartum weight retention, women in the postpartum period are a critical population where weight management interventions should take place in order to combat the onset of obesity.

Many methods exist to combat obesity including aerobic exercise interventions as well as diet modifications. Resistance training is included in physical activity recommendations made by the U.S. Surgeon General and the American College of Sports Medicine because of the many health benefits associated with it (17). Some of the benefits include increases in muscle mass and increases in resting metabolic rate (22). Muscle mass requires more energy at rest than fat mass, therefore, the more muscle a person has the more calories they will expend. Given this theory, engaging in resistance training can be an essential tool for weight management. In addition, resistance training is also seen to help maintain bone mineral density (41). Because osteoporosis is prevalent among women as they age, engaging in resistance training should be an essential component of fitness for women.

This review focuses on research that sheds light on the following three topics; a) weight retention among postpartum women, b) weight management interventions for postpartum women, and c) strength training in premenopausal women.

Weight Retention among Postpartum Women

Many researchers have completed studies to determine the extent of which weight retention occurs after pregnancy and delivery. From the studies completed, researchers have found that postpartum weight retention can vary greatly among women. In addition, they have also found relationships between weight retention and excessive gestational weight gain as well as prepregnancy weight.

Variability of Postpartum Weight Retention

Postpartum weight retention is variable for women. Some studies have shown that some women have little difficulty returning to their prepregnancy weight, while others studies show women retain much of their pregnancy weight. Some women even gain weight during the postpartum period. The typical weight retention range due to pregnancy is about -0.27 kg to 3 kg (11). Greene, Smiciklas-Wright, Scholl, and Karp (1988) investigated a sample of 7,000 women from the beginning of one pregnancy to the beginning of a second pregnancy. On average, the change in weight between these two time periods was positive 3.4 kg (12). In addition, they found that 73% of the women weighed more at the beginning of their second pregnancy when compared to the beginning of the first (12). The strength of this study is merited to the large sample size and shows that the majority of women retained weight from their first pregnancy.

Conversely, Harris, Ellison, Holliday, and Lucassen (1997) measured women at the same two time periods only they controlled for age-related weight gain. The results of their study showed an average weight change to be -0.27 kg (16). They also found that 70.8% of the mothers gained less than 1.0 kg and 24.7% gained more than 1.54 kg (16). The results from this study do not significantly attribute weight gain due to pregnancy; it seems difficult to discern weight gain due to pregnancy from weight gain due to age increase. Therefore, although controlling for age may isolate weight gain due to pregnancy, the fact that weight gain does occur may be a more important issue. In addition, only 240 mothers were included in this study.

In another study completed by Harris, Ellison, and Clement, (1999) they looked at weight change from the first trimester to 2.5 years after pregnancy. The range of weight retention among their population was between a 17.7 kg gain to a 13.6 kg loss (15). Such a broad range makes it difficult to determine the way in which pregnancy contributes to weight gain. These studies demonstrate the great variability that exists for weight retention among postpartum women. However, some women are gaining as much as 17 kg (37 lbs) which is a significant gain worthy of valid concern. Furthermore, Gunderson and Abrams (2000) conclude that up to 20% of the women from their study retained excessive amounts of weight after pregnancy (13). These high-risk women would certainly benefit from weight management interventions to help them control their weight.

In a study completed by Rooney and Schauberger (2002), they investigated postpartum weight retention ten years following childbirth in 540 mothers. They reported that the women who lost all of their pregnancy weight by six months postpartum were an average of 2.5 kg heavier ten years later, regardless of whether they breast-fed or not (30). Of the women who retained weight after pregnancy, they were found to be an average of 8.3 kg heavier at the 10-year follow up (30). This is a difference of 5.8 kg (12.8 lbs). As a result of this 10-year follow-up study, the authors report that the failure to lose pregnancy weight by six months postpartum is a predictor of weight gain and obesity in years to follow (30). Furthermore, they found that only 37% of the women were actually able to return to their prepregnancy weight six months after childbirth (30). Given their results, the first six months after childbirth is a critical period where interventions should take place to help women return to their prepregnancy weight. The fact that less than 40% of women are typically seen to accomplish such a milestone further reiterates the importance of postpartum interventions.

Similar results were obtained in a study completed by Linné, Dye, Barkeling, and Rössner (23). In this study, they investigated 563 women 15 years following childbirth. They found that weight retention one year postpartum was predictive of future overweight and obesity (23). These studies provide great evidence that although weight retention is variable in postpartum women, it is in fact common and can lead to overweight and obesity in years following childbirth. Therefore, interventions to target postpartum women may be imperative actions in order to attenuate overweight and obesity rates in the United States.

Excessive Gestational Weight Gain

Research has shown that excessive gestational weight gain may lead to greater retention after pregnancy. Healthy weight gains have been established for pregnant women based on their prepregnancy BMI. As BMI increases, the amount of necessary weight gain decreases. For women with a BMI between 26 and 29 (overweight), the recommendation is a gain between 7 and 11.5 kg (18). A study completed by Scholl, Hediger, Shall, Ances, and Smith (1995) reported that women who exceeded the recommendations for weight gain weighed 12% more than their prepregnancy weight at six months postpartum. Those who gained the recommended weight or less weighed between 5% and 7% more at six months postpartum (34). The difference between these two groups is significant and shows how excessive weight gain during pregnancy can contribute to even more weight retention. Those that gain excessive weight during pregnancy are therefore considered to be at higher risk for weight retention after pregnancy, which may lead to obesity and other health problems.

Prepregnancy Weight Status

Some research shows that being overweight prior to becoming pregnant may contribute to increased postpartum weight retention. In a study completed by Ohlin and Rössner (1990) all of the women who retained greater than 16 kg at one year postpartum had a prepregnancy BMI of 26 (indicating overweight) or more (27). Although a linear relationship was not found between prepregnancy weight and postpartum weight retention, this study does show a significant relationship between excessive weight gain and prepregnancy overweight status. In addition, a study by Soltani and Fraser (2000) showed that women with normal prepregnancy weight had lost more fat at six months postpartum based on waist-to-hip ratios and skinfold measurements (37). These studies suggest that women who are overweight before pregnancies may be at greater risk for postpartum weight retention. Although weight retention is variable among postpartum women, a prevalence of weight retention does exist, especially in high risk individuals with excessive gestational weight gain or high prepregnancy BMI. Therefore, weight management interventions are necessary to help prevent further weight gain.

Weight Management Interventions for Postpartum Women

Various interventions strategies have been used to help women manage their weight after pregnancy. Some interventions have proven to be more effective than others. Interventions commonly used include exercise prescription only, exercise prescription plus diet modifications, and the use of correspondence tools.

Exercise Only Interventions

Lovelady, Nommsen-Rivers, McCrory, and Dewey (1995) completed a study where sedentary postpartum women participated in supervised aerobic exercise sessions for 45 minutes at an intensity of 60% -70% maximum heart rate five days a week for twelve weeks. A control group did not participate in exercise. In the end, the exercise group had a 25% increase in VO_2 max compared to a 5% increase in the control group (25). However, body fat percentage decreased in both groups with no significant differences between groups (25). This may be due to the possibility that the exercise group consumed additional calories to compensate for the extra calories expended through exercise. Another possibility could be that because the exercise group participated in regular, scheduled exercise, the group may not have participated in as much spontaneous physical activity. This study suggests that interventions that emphasize exercise alone may help postpartum women achieve cardiovascular fitness gains, but may not be enough to further weight loss.

Exercise Plus Diet Interventions

O'Toole , Sawicki, and Artal (2003) completed a study on two groups of postpartum women who were 5 kg above their prepregnancy weight. The first group received individualized exercise and diet prescriptions, kept daily diaries for food and activity, and met for group sessions. The exercise programs were not discussed in detail, but were designed to increase energy expenditure by 150 kcal per day and encouraged regular aerobic activity at moderate intensities based on heart rate, but the exercise sessions were not supervised (28). The second group, or control group, attended one session where tips were given for weight loss. At the end of the study, only 23 out of 40 subjects remained in the study. A significant difference in body composition between the remaining subjects of the two groups was an outcome of the study. These changes included decreases in body fat among the exercise group, but there were not significant changes in fat-free mass (28). From this study assumptions can be made that exercise and diet interventions can prove to be effective in helping women lose weight after childbirth. However, resistance training recommendations may be able to increase fat-free mass and improve body composition even further (33).

Correspondence Interventions

In a study completed by Leermakers, Anglin, and Wing (1998), the effectiveness of a correspondence intervention was analyzed (21). The intervention group attended two group sessions toward the beginning of the study where they received instruction on how to start losing weight by participating in aerobic exercise and following a diet where calorie and fat intake were restricted. The intervention group also received 16 written lessons about weight loss in the mail weekly. The last component of the correspondence intervention was that every member received regular phone calls with a staff member to discuss how everything was going. The control group members were given a brochure that contained tips on healthy eating and exercise and received no other contact throughout the duration of the study.

At the end of the study, the intervention group lost significantly more weight with an average of 7.8 kg compared to an average 4.9 kg lost by the control group (21). In addition, 33%

of the correspondence group returned to their prepregnancy weight compared to only 11.5% in the control group (21). This study shows that a correspondence intervention that includes information about behavior change, exercise, and diet, may be effective for women in the postpartum period.

Although many interventions have been used to assist postpartum women to lose pregnancy weight, the effectiveness of these interventions is mixed. None of the exercise interventions incorporated resistance training; therefore more research is needed in this area of study.

Resistance Training in Premenopausal Women

Virtually no studies exist examining the effect of resistance training in postpartum women. However, many studies have been completed to see how resistance training affects young, premenopausal women. Studies have specifically focused on how resistance training affects strength gains, body composition, and bone mineral density.

Resistance Training Effects on Strength Gains

The majority of resistance training studies show greater strength gains in the training group compared to the control group. The same exists in studies done specifically among premenopausal women. In a study completed by Chilibeck, Calder, Sale, and Webber (1996), untrained young women participated regularly in a split body resistance training program for twenty weeks. Training sessions included five sets of 6 to 12 repetitions. At the end of the study, posttesting indicated significantly greater strength gains in the training group based on one-repetition maximums (1 RM). All members of the training group achieved increases in 1 RM by averages of 73% for the arm curl, 33% for the bench press, and 23% for the leg press (6). Similarly, Cullinen and Caldwell (1998) found consistent findings in another study completed in untrained young women. Cullinen and Caldwell found that participating in twice weekly resistance training sessions with three sets of 10 repetitions for six exercises produces significant strength gains over a period of twelve weeks. They saw strength gains in the women for elbow flexion from an average of 28.9 to 34.5 lbs (7). For the elbow extension, strength increased from an average of 16.9 to 22.1 lbs, and for knee extension, strength increased from an average of 39.5 to 48.6 lbs. (7). These studies in addition to others show how engaging in a strength training program proves to increase strength gains among premenopausal women.

Strength Training Effects on Body Composition

Muscle mass requires more energy than fat mass, even at rest (22). Because of this physiological principle, it can be assumed that strength training may be a key component to weight management interventions. Like strength gains, virtually no studies exist that evaluate how resistance training influences body composition elements in postpartum women. However, several studies have observed the effects resistance training has on body composition in premenopausal women. Schmitz, Hannan, Stovitz, Bryan, Warren, and Jensen (2007) completed a study in this area of question. The study looked at how effective a twice-weekly resistance program is in helping avoid excess fat gain typical among women as they age. The training group participated in resistance training twice a week for two years. All sessions were supervised and consisted of three sets of 8-10 repetitions for 8-10 exercises. At the end of the two years, the training group experienced changes in body fat percentage by -3.68% ± 0.99% (32). The changes in body fat percentage were due to increases in lean mass as well as decreases in fat mass (32). The control group was simply given a brochure at the beginning of the study recommending aerobic exercise. In the end, the control group experienced body fat changes of -

0.14 ± 1.04% (32). Schmitz et al. observed how twice-weekly strength training can help women delay the onset of fat gains and can even decrease body fat percentage further.

In another study completed by Schmitz et al. (2003), similar findings were observed. In this study, the training group participated in fifteen weeks of supervised strength training two times a week, and then participated in six months of unsupervised twice-weekly strength training. This was done in order to see if women could accomplish unsupervised training for six months. At each session, participants completed three sets of 8-10 repetitions for nine exercises. Among the women, almost 90% of the prescribed strength training sessions were completed (33). The treatment group gained 0.89 kg more fat-free mass, lost 0.98 kg more in fat mass, and lost 1.63% more in percent body fat in comparison to the control group that was studied (33). This particular study shows how strength training can help prevent weight gain as women age and also that a twice-weekly strength training program is feasible for busy women.

Chilibeck et al. (1996) and Cullinen and Caldwell (1998) found similar results when analyzing the effects of strength training on body composition (6,7). Using dual energy x-ray absorptiometry (DXA), Chilibeck et al. (1996) observed significant increases in fat-free mass among women in the training group. They observed a whole body increase of lean mass of 3.7%, as well as 3.0% increase in the trunk, 9.7% increase in the arm, and 3.3% increase in the leg (6). In a study performed by Cullinen and Caldwell (1998) the training group participated in twice-weekly strength training for twelve weeks. Cullinen and Caldwell found the training group increased fat-free mass from averages of 44.2±5.4 kg to 46.4±6.0 kg and decreased percent body fat from 29.8% ±2.8 to 27.2% ±2.6 (7). These studies further suggest that strength training can positively affect body composition in premenopausal women.

Although most studies show a positive relationship between strength training and fat-free mass, the studies did not show significant differences in body mass. The authors suggest that a combination of strength training and aerobic activity coupled with good nutrition may be most effective when trying to positively influence all components of body composition. Because all of these studies have been completed on premenopausal women, it is difficult to know how postpartum women will respond to resistance training interventions. More research is needed to determine the effectiveness of resistance training to improve body composition components in postpartum women.

Another component of body composition is bone mineral density. It is thought that mechanical loading, especially loads produced by muscle forces result in the largest strains on bones, therefore causing the bone to adapt in strength (20). Despite this theory, about seven randomized studies have assessed the way resistance training effects bone mineral density in premenopausal women, with mixed results. A few studies have shown that engaging in resistance training can positively affect bone mineral density (9,24,36). Conversely, other studies show that engaging in resistance training produced no significant effect on bone mineral density (8,35,41,40). Although results are mixed for premenopausal women, no studies have been completed to assess resistance training and its effects on bone mineral density in postpartum women. Therefore, more research is needed to determine how resistance training affects bone mineral density in women.

Conclusions

It is evident that weight retention as a result of pregnancy is prevalent among women and may even contribute to the escalating rates of overweight and obesity in the United States. Many studies have looked at exercise and diet interventions to encourage postpartum weight loss.

Some studies appeared to be effective for weight loss, however, few, if any studies have incorporated resistance training into the interventions. As a result, many of the studies failed to see increases in fat-free mass. Because of the way resistance training has been found to positively affect strength gains, fat-free mass, body fat percentage, and bone mineral density, it is suggested that strength training be included in postpartum weight management interventions. Likely, a combination of aerobic exercise, strength training, and diet modifications is necessary and most effective in bringing about changes in body composition. But because virtually no studies have incorporated strength training as a weight management strategy in the postpartum population, the proposed study will be performed to determine the effectiveness of resistance training in women with postpartum weight retention. This innovative study has the potential to improve the weight management tools used by health professionals when counseling postpartum women who want to return to their prepregnancy weight and may even help lower the incidence of obese women in the United States.

Chapter 3

Methods

Design

To accomplish the purpose of this study, 60 postpartum women will be randomly assigned into one of two groups, an intervention group or a comparison group. Group 1 (resistance training group) will participate in progressive resistance training for four months. They will complete a resistance training session two times each week over the four-month period. For each training session, the women will perform nine exercises. Each exercise will consist of one to three sets of 10 repetitions. During the first month all sessions will be supervised and thereafter, every other session will be supervised. Group 2 (flexibility group) will be provided with a twice-weekly flexibility program and will be invited to participate in group stretching sessions once per week throughout the four-month study. Both groups will participate in baseline, month 2, and month 4 data collection (see below).

Participants

This study will be approved by the Institutional Review Board at Brigham Young University (BYU) and all participants will be required to sign an informed consent document before beginning the study. For this study, 60 healthy postpartum women will be recruited from the BYU and Utah County communities who have recently given birth. Upon recruiting, all women will be at least 5 lbs above their prepregnancy weight. The women must be at least six weeks postpartum and no more than eight months postpartum. All women must receive medical clearance from their physician in order to be a participant for this study. All women will complete a PAR-Q and health history that will identify risk factors. Women will be included in the study as long as they have no contraindications from the PAR-Q and health history, have not participated in a resistance training or flexibility programs in the past six months, are nonsmokers, and have social support allowing them to complete a resistance training workout twice weekly or the weekly group flexibility sessions. Women will be excluded from the study if they have contraindications from the PAR-Q or health history, if they are unable to perform resistance training or moderate intensity exercise, or if they have engaged in resistance training or flexibility training twice or more per week within the last six months. In addition, women will be excluded if they are planning to participate in a commercial diet, if they are planning to become pregnant in the following year, or if they are planning to leave the area in the following year.

All women will be recruited from the Brigham Young University community and Utah County by way of posters, fliers, BYU campus mail, and word of mouth. Hospitals, obstetric clinics, and pediatric clinics in Utah County will also be utilized for recruitment.

Procedures

Resistance Training Group

For the first month of the study, the participants will be given access to resistance training equipment at a local physical therapy clinic (Central Utah Clinic, Sports Fitness and Physical Therapy, Sports Acceleration, 1055 North 500 West, Provo, UT 84604) twice a week on nonconsecutive days for supervised workouts. Supervision will be accomplished with the use of research assistants. Each participant will be supervised by a research assistant to verify that the exercises, sets, and repetitions are completed correctly based on the protocol of the study. Each workout will consist of 9 resistance exercises to challenge all the major muscle groups of the body. For each exercise, one set of 10 repetitions will be completed. The subjects will rest for at least 90 seconds between repetitions. Each exercise session will take approximately 30 to

40 minutes to complete, therefore the subjects will spend 60 to 80 minutes performing resistance training each week. The amount of resistance will be 70%-80% of their estimated 1RM determined at the collection periods or a weight that can be performed for 8-12 repetitions for each exercise. Estimated 1RMs will be calculated using the Bryzycki equation (3). The formula uses the amount of resistance lifted where the subject can only complete between 2 and 10 repetitions to estimate the 1RM and is as follows:

$$1\text{RM} = \text{weight lifted (lb)} / [1.0278 – (\text{reps to fatigue} \times 0.0278)]$$

In addition, the program will be progressive in volume and intensity. After >12 repetitions can be performed on the last set, the weight will be increased by 1 machine increment or 2%-10%. The exercises will include leg press, leg extension, leg curl, biceps curl, shoulder press, chest press, lat pull-down, seated row, and crunches.

Leg Press. The leg press exercise works to target the muscles of the quadriceps, hamstrings, and gluteals. To do the leg press the participants will sit in the machine and grasp the handles on both sides of the seat and put their feet on the plate. To ensure leg strength is determined in a consistent manner among participants, the leg press exercise will begin from a 90 degree knee angle, which will be verified by a goiniometer. Once the angle (as close to 90 degrees as possible) is obtained, the hole used on the machine will be documented and used throughout the study. With both feet on the plate, they will press their legs forward until they are fully extended. They will then return to the starting position (1).

Leg Extention. To isolate the quadriceps muscles, the leg extension will be performed. The leg extension will be completed by the participants sitting in the machine with knees flexed to about 90 degrees and with their feet placed behind the pads of the machine. They will then fully extend their legs and then return the starting position (1).

Leg Curl. To isolate the muscles of the hamstrings, a seated leg curl will be part of the prescribed program. The leg curl is completed by the subjects sitting in the machine with their legs extended and their feet placed on top of the pads of the machine. They will then bend their legs at the knee toward the buttocks until their knee forms a 90 degree angle. They will complete one repetition by then returning to the starting position (1).

Biceps Curl. To isolate the biceps muscles in the arms, biceps curls will be performed. The biceps curl can be done by grasping a bar about the width of the shoulders using a palms-up grip. To start, the arms are extended and the bar should rest against the thighs. The bar is then curled up toward the shoulders and then returned to the starting position (1).

Shoulder Press. The muscles in the shoulder will be emphasized by doing the shoulder press. The shoulder press will be completed using dumbbells. Subjects will sit on a bench with feet flat on the floor. They will grasp the dumbbells and bring them to shoulder level with palms forward. They will then push the dumbbells overhead until the arms are fully extended and then lower the dumbbells to the starting position (1).

Chest Press. To work the pectoral muscles, the chest press will be used. The chest press will be completed using an upright chest press machine. The seat should be set so that the handles are at the chest level and as close to the chest as possible. They will then push the handles forward until the arms are fully extended and then return to the starting position (1).

Lat Pull-Down. To isolate the muscles of the upper back, subjects will complete the lat pull-down. The lat pull-down is completed using a machine. The subjects will be sitting and will grasp the bar in a wide grip with arms fully extended. They will then pull the bar down in front of the body until it reaches the upper chest and then return to the starting position (1).

Seated Row. The muscles of the mid-back will be targeted by completing the seated row exercise. To begin the seated row, the participants will sit in the seat of the machine. With arms extended and back straight, they will grasp the handles in front of them with a palms-down grip. They will then pull the handles toward the body until it touches the lower chest (1).

Crunches. To target the abdominal muscles, the subjects will perform crunches. Crunches are completed by lying in the supine position with knees bent and feet flat on the floor. Arms are folded across the chest and the subject will curl up to about a 30 degree angle, and then return to the starting position (1).

All exercises will be performed in a slow and controlled motion, not jerky or fast. To ensure safety, the subjects will be told to keep their mouth open while performing the exercises. Having the airway closed during lifting can produce the valsalva effect, which occurs due to increased blood pressure and may cause the individual to faint (2).

For the second month the participants will attend one supervised workout each week. Additionally, each week they will be asked to complete a second workout on their own on a nonconsecutive day as the first. For unsupervised workouts the women will receive a log to record the date, exercises performed, amount of resistance, and sets and repetitions completed. Logs will be turned in prior to each supervised session in order to verify their participation and for adjustments to be made to their upcoming workout. The participants will also progress to two sets of nine exercises. For the first set, the women will perform 10 repetitions of each exercise. For the second set, the same weight used for the first, only the women will complete as many repetitions as possible. If they can perform more than 12 repetitions on the second set, the amount of resistance will be increased for the following training session by one machine increment or 2%-10% of their 1RM for each set and for each exercise.

For months three and four, the participants will continue to attend one supervised workout and complete a second, unsupervised workout on a nonconsecutive day each week. They will continue to record the date, exercises performed, sets, repetitions, and amount of resistance of their unsupervised workouts on logs provided to them. They will turn in their report prior to their supervised workout in order for adjustments to be made to their upcoming supervised workout. For these months the participants will progress to three sets of the nine exercises. The resistance will be set at a weight where the participant can complete 10 repetitions for the first and second sets. On the third set, they will complete as many repetitions as possible. The weight will continue to increase by one weight machine increment or 2-10% when the participant is able to perform >12 repetitions on the third set of a given exercise.

Throughout the four months, the participants will be asked to abstain from participating in additional resistance training and with the cardio equipment in the weight room. Having access to cardio equipment will give the resistance training group an unfair advantage over the flexibility group. In order to control for this confounding variable, the resistance training group will be asked not to use the cardio equipment at the gym. However, all participants will be allowed to participate in aerobic activity on their own.

Flexibility Group

The flexibility group will be asked to participate in a flexibility program based on the recommendations from the ACSM (2). These guidelines include participating in stretching two nonconsecutive days per week. Each stretching session will include four sets per muscle group and each stretch will be held between 10 and 30 seconds. Each flexibility session will take about 20 to 30 minutes; therefore, subjects will spend between 40 and 60 minutes stretching each week. Flexibility exercises will target the following major muscle groups: low back and hamstrings, quadriceps, calves, neck, arms, and torso.

To stretch the hamstrings and lower back, the subjects will perform four sets of different stretches. The first stretch is a sit-and-reach where the subject will sit with legs together out in front of them and with their feet flexed. They will then lean forward with their arms extended over their legs and hold the stretch for 10 to 30 seconds. The second stretch is similar to the sit-and-reach only the subject will have only one leg extended out at a time. They will then lean forward over the leg and hold the position for 10 to 30 seconds and will repeat with the other leg extended. The third stretch will be completed by the subject sitting up with the legs straddled to the sides. To stretch, the subject will lean forward in between their legs and also to both sides. They will hold each position for 10 to 30 seconds. The fourth stretch will be done by the subjects lying on their back. They will then bring their knees to their chest and hold the position for 10 to 30 seconds.

To stretch the quadriceps muscles, the subjects will complete two stretches on each leg equaling 4 sets. For the first stretch, the subjects will stand erect and gradually pull the heel of one foot up to the buttocks. They will hold the stretch for 10 to 30 seconds and will repeat with the other leg. The second stretch will be done by having the client lying on their left side with the left elbow supporting their body. They will then pull the heel of the right leg toward the buttocks and hold the stretch for 10 to 30 seconds. They will then repeat the stretch for the other leg.

The subjects will stretch muscles in their calves by doing the gastrocnemius and Achilles tendon stretch.   The subjects will stand while leaning toward a wall. They will then extend one leg behind them while the front leg is slightly bent. They will hold this stretch for 10 to 30 seconds and then repeat it on the other leg. To stretch the lower muscle of the calves, the soleous and Achilles tendon, the client will bend the back leg slightly and hold the stretch for 10 to 30 seconds for each leg.

To stretch the muscles in the neck, four stretches will be completed. The first stretch is the lateral neck stretch. The subject will use their hand to gently pull their head as if they were trying to touch their ear to their shoulder. This will be held for 10 to 30 seconds and repeated to the other side. The second stretch is where the subject will turn their head to the side. They will hold the stretch for 10 to 30 seconds and then repeat the stretch to the other side. The final stretch for the neck will require the subjects to extend their head forward as if to touch their chin to their upper chest. They will hold this stretch for 10 to 30 seconds and repeat a second time.

For the arms the subjects will complete four different stretches. To stretch the triceps brachii, the subjects will lift one arm so that the elbow is next to the ear and place the hand between the shoulder blades of the back. They will then gently push the elbow back with the other hand until they feel a stretch. They will hold the stretch for 10 to 30 seconds and repeat for the other arm. To stretch the bracioradialis, the subjects will kneel on all fours with their palms on the ground and with fingers pointing toward their knees. They will hold this stretch for 10 to 30 seconds. The shoulder abductors will be stretched by having the subject in the standing position. They will then place their right arm behind their back and use their left arm to gently stretch the right arm for 10 to 30 seconds. They will then repeat the stretch for the left arm. To stretch the lateral shoulder, the subjects will bring their right arm across the front of the body. They will use their left hand to gently grab the elbow and pull the right arm until they feel a stretch in their shoulder. They will hold the stretch for 10 to 30 seconds and repeat on the left arm.

The muscles in the torso will be stretched by doing four different stretches. To stretch the chest, they will perform the pectoralis stretch. To do this the subjects will stand in a corner or in a doorway with their hands above their head and elbows making a 90 degree angle at the shoulder level. They will then lean forward until they feel a comfortable stretch across the chest. They will hold the stretch for 10 to 30 seconds. To stretch the upper back the subjects will stand and lean forward by flexing the hip. They will lean forward so their arms are extended and hands resting on a wall. They will hold the stretch for 10 to 30 seconds. They will stretch the abdomen and hip flexors by lying on their stomach with their upper body supported on their forearms. They will then dig their elbows into the floor causing the abdominal muscles to stretch. They will hold the stretch for 10 to 30 seconds. They will further stretch muscles in their back and torso by completing the overhead stretch. Standing erect, the subjects will lift both arms above their head and stretch as far as they can (at a comfortable level). They will hold the stretch for 10 to 30 seconds.

All stretches will be performed using controlled motions. Bouncing while stretching will be discouraged. The subjects will also be told to breathe normally as they stretch and to only hold the stretches at a level where they feel comfortable. They should not feel great pain as they stretch.

The participants will be given the opportunity to attend a weekly, supervised group stretching session located on the BYU campus for the duration of the study. Each session will be about 30 minutes in length and will be conducted by a research assistant. In addition, the subjects will be expected to participate in stretching sessions on their own twice weekly. The subjects will be asked to keep a log of stretching sessions completed on their own during the four months of the study. The log will prompt the subjects to record the date, stretches completed, and length of time the stretches were held.

Measurements and Methodologies

Data collection will take place at baseline, two months, and four months. Each data collection period will consist of two separate visits at least 8 days apart. The reason for the length of time between visits is to collect additional data that will not be included for this thesis. At visit one all subjects will sign the informed consent document, as well as discuss aspects of the study with a research assistant. They will also take part in the flexibility assessments and practice the strength assessments. At visit two all subjects will participate in body composition, anthropometric, strength, and bone density assessments.

Body Composition

Body composition and anthropometric measurements will be taken for both groups at visit two of baseline, two-month, and four-month collection periods. Body weight will be obtained using a digital scale (Life Measurement, Inc., Concord, CA) with the subjects wearing the standardized clothing, a bathing suit, which will be provided for them. Height will be measured using a wall-mounted stadiometer. BMI will be calculated as kg/m^2. To assess fat mass, fat-free mass (FFM), and body fat percentage, the dual energy x-ray absorptiometry (DXA)—(Hologic Inc, Massachusetts) will be used. The DXA is widely used and accepted as a valid and reliable measure of whole body composition (10,39). Radiation exposure from the DXA to operators and patients is 1/10th that of an X-ray and does not pose as a hazard to safety or health. Participants will be tested after abstaining from food, caffeine, and exercise for at least three hours.

Total body bone mineral density and hip bone mineral density will be measured on the flexibility group and the resistance training group at visit two on baseline, two-month, and four-month collection periods. Whole body and left hip measurements will be taken using the DXA (Hologic Inc, Massachusetts) and according to the protocol suggested by the manufacturer. For the whole body measurement, the subjects will be in the supine position with their arms to the side and palms down. Their legs will be rotated inward about 25 degrees and a Velcro strap will be used to keep the legs in the position. They will need to hold still and relax for the duration of the test (about six minutes). The left hip measurement will be taken by ensuring the spine is straight. The left leg will be rotated inward 25 degrees and the foot flexed. The test will take about 1 minute. The measurements will be taken at the same time as the body composition upon abstaining from food, caffeine, and exercise for at least three hours.

Waist measurements will be taken as the subject stands with arms at the side and feet together. A horizontal measure will be taken at the narrowest part of the torso, which is generally above the umbilicus and below the xiphoid process (2). Abdominal circumference will be assessed with the subject standing upright and relaxed with arms to the side. The horizontal measurement will be taken at the level of the umbilicus (2). Hip measurements will be taken with the subject standing upright with feet together. A horizontal measurement will be taken at the largest circumference of the buttocks (2). Each measurement will be taken using a spring loaded measuring tape. At least three measurements, within 2 cm, will be taken to ensure accuracy. The average of the three measurements will be used.

Strength

Strength will be assessed for the participants of both groups at visit two of baseline, two-month, and four-month collection periods. At visit one of baseline testing, the subjects will be able to practice the strength assessment exercises to become familiar with the exercises and technique. During visit two of baseline testing, the estimated 1RM will be determined for three exercises (leg press, chest press, and abdominal curl-ups) for every participant. Prior to testing, the subjects will warm-up with low-intensity aerobic exercise (walking) for five minutes. They will also complete 10-20 sub-maximal repetitions for each test exercise. To reduce chance of injury sometimes associated with maximal strength testing, strength will be determined from the leg press and bench press using resistance in which the subject can perform 3-8 repetitions. For the leg press, the subject will sit in the machine so the knee is flexed to as close to 90 degrees. The angle will be verified by a goiniometer. The hole of the machine in which the 90 degree angle is closest to will be noted for each subject and used in all tests at the data collection periods. For the seated bench press, the subjects will sit in the machine so that the handles are at the level of their chest and as close to the chest as possible. An initial weight will be selected that is within perceived capacity of the subject. The weight will progressively increase by no less than 5 lbs until no more than 8 repetitions can be completed at a given weight. Between each weight increase, the subjects will rest for at least three minutes. Their 1RM will be estimated or predicted based on their performance. The predictions will be made using the following equation (3):

$$1RM = \text{weight lifted (lb)} / [1.0278 - (\text{reps to fatigue} \times 0.0278)]$$

To assess abdominal strength, the ACSM partial curl-up (crunch) test will be administered to all participants (2). The individuals will lie in a supine position with knees flexed at a 90 degree angle and arms at the sides with fingers touching a piece of masking tape on the mat. A second piece will be placed 10 cm beyond the first piece. A metronome will be set to 40 bpm. The client will slowly lift their shoulder blades off the mat and lift their torso until their fingers reach the second piece of tape. The test will be scored based off the number of crunches the subjects can complete while staying on the cadence and keeping the correct form.

Flexibility

Flexibility will be assessed at visit one at baseline, two-month, and four-month collection periods. It will be assessed using three measurements of flexibility. The measurements include the V sit-and-reach test (YMCA sit-and-reach test), the standard sit-and-reach test, and the skin distraction test. To warm-up, each subject will participate in about five minutes of aerobic exercise (walking) and will stretch for about 30 seconds on each stretch they will be tested on. For all tests the subjects will be reminded not to stretch in fast or jerky motions but to slowly stretch and hold at their maximum stretch. The V sit-and-reach will be administered by placing a piece of tape that is 12 inches long on the floor, perpendicular to the 15 inch mark on a yard stick secured to the ground (42). The subjects will sit straddling the yard stick with their heels at the 15 inch mark, 12 inches apart. The legs should be extended, but not locked. The subjects will then lean forward with arms extended and reach as far as they can and hold the stretch for three seconds. The scores will be ranked based on the percentile ranks established by the YMCA according to age and gender (42). The standard sit-and-reach test, from the Canadian Society of Exercise Physiology (CSEP), uses a box where the zero mark is on the edge of the box (4). The subjects will sit with legs together, knees extended, and the soles of their feet against the edge of the box. They will then reach forward with arms extended along the top of the box and reach as far as they can. They will hold the stretch for about three seconds. Scores will be interpreted by using established percentile ranks from the CSEP (4). The last test is the skin distraction test, which assesses low back flexibility (38). For this test the subject will stand upright. A mark will be placed at the midline of the lumbar spine and will be labeled as 0 cm. A second mark will be placed 15 cm above the first mark. The subjects will then bend forward at the waist as far as they can and the distance between the marks will be measured. The difference between the original length and flexion length will indicate the subjects' scores. All tests will include two trials. The best scores from the trials will be used.

Statistical Analysis

PC-SAS will be used to analyze all descriptive and outcome data (body composition, anthropometrics strength, and bone density). Independent Ttests will be used to determine differences in descriptive data at baseline. Mixed Effects models will be utilized to determine differences within groups and between the groups over the duration of the study and to determine whether or not a group-time interaction is present. Where appropriate, control variables will be added, including number of children, weight gain during pregnancy, initial strength, initial body composition, and time postpartum upon initiating the study.

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