Effect of resistance training on body composition, self-efficacy, depression, and activity in postpartum women


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This study assessed the effect of resistance training (RT) in 60 healthy postpartum women. Participants were randomized to 18 weeks of RT or an active comparison group (flexibility training). RT and flexibility training (FT) exercises were completed twice-weekly based on the American College of Sports Medicine recommendations. Study outcomes included muscular strength, body composition (dual-energy x-ray absorptiometry), exercise self-efficacy, depressive symptoms [Center for Epidemiological Studies Depression Scale (CES-D)], and physical activity (accelerometry). For completers ($n = 44$), the RT group showed greater strength gains than the FT group, respectively (bench press: +36% vs +8%, $P < 0.001$; leg press: +31% vs +7%, $P < 0.01$; abdominal curl-ups: +228% vs +43%, $P < 0.01$); however, body composition changes were not different. There was a significant group $\times$ time interaction for exercise self-efficacy ($F = 5.33$, $P = 0.026$). For CES-D score, the RT group decreased ($F = 4.61$, $P = 0.016$), while the FT group did not; however, the group $\times$ time interaction in CES-D score was not significant ($F = 1.33$, $P = 0.255$). Sedentary time decreased ($F = 5.27$, $P = 0.027$) and light-intensity activity time increased ($F = 5.55$, $P = 0.023$) more in the RT than FT group. Intent-to-treat analyses did not alter the results.

Twice-weekly RT increases strength and may be associated with better exercise self-efficacy and improved physical activity outcomes compared with FT in postpartum women.

Methods

This study was approved by the university’s Institutional Review Board and all participants provided informed consent. Participants...
were recruited from the local community and 60 postpartum women ($n = 30$/group) were enrolled in the study. Thirty participants per group was a conservative estimate as 25 participants per group yields a power of 0.79, based upon a moderate effect size (0.4) for fat-free mass. All participants were healthy enough for PA according to the Physical Activity Readiness Questionnaire (PAR-Q). Each participant provided a signed physician’s release form indicating that she was healthy enough to participate. Participants were between 6 weeks and 8 months postpartum, >2.27 kg above their self-reported pre-pregnancy weight, not planning to become pregnant over the subsequent year, non-smokers, and able to perform twice-weekly training. A minimum of 6 weeks following childbirth was required for study participation in order to allow for sufficient recovery. The 8-month limit was chosen to allow for completion of the RT intervention within a year postpartum. Exclusion criteria were as follows: inability to perform RT or moderate-intensity exercise, engaging in RT or moderate intensity exercise, or participation in a weight-loss program.

Participants were randomized to a twice-weekly FT group or an active comparison group that performed twice-weekly flexibility training (FT). Randomization was accomplished using the statistical software package PC-SAS (SAS Institute, Cary, North Carolina, USA). Randomization followed baseline assessments; thus, initial assessments were blinded to group assignment. FT was chosen instead of a passive control group in order to decrease the likelihood of withdrawal from the study. Except for the completion of the training protocol and avoidance of RT in the FT group, there was no other restriction or instruction for dietary intake or other PA.

Resistance training intervention

Each participant in the FT group was provided a 4-month (18 weeks) membership to a local physical therapy clinic to ensure access to the appropriate RT equipment. The FT protocol was based on recommendations from the American College of Sports Medicine (ACSM) and American Heart Association (Haskell et al., 2007) and included the following: nine exercises for all major muscle groups, 1–3 sets per exercise, 90-s rest interval between sets, and 8–12 repetitions per set performed on 2 non-consecutive days per week. The RT exercises included leg extension, seated leg curl, leg press, biceps curl, shoulder press, chest press, lat pull-down, seated row, and abdominal curl-ups. All RT exercises were performed via machines except the shoulder press, which was performed using dumbbells.

The RT protocol was progressive. During the first month, the RT participants completed a single set of each exercise per workout session, two sets per exercise per session during the second month, and three sets per exercise per session during months 3 and 4. At the first training session, each RT participant, guided by her trained supervisor, gauged her exercise weight based on the weight she felt she could accomplish for 8–12 repetitions. When participants could perform two or more repetitions over the prescribed amount for any given exercise, the weight was increased by one machine increment or ~2–10% (Kraemer et al., 2002). In this way, there was continuous overload for all participants.

During the first month, all training sessions for each participant were supervised to ensure proper form and lifting technique. During months 2–4, at least one session per week was supervised and non-supervised sessions were verified, via exercise record.

FT intervention

The twice-weekly FT protocol was based on the recommendations from the American College of Sports Medicine Position Stand (1998) and included static stretching, four stretches (sets) per major muscle, and holding each stretch for 10–30 s. Flexibility sessions were not supervised; however, each participant in the FT group was provided a written description of how to do each stretch, recorded their progress on a stretching record, and had the option of participating in a group stretching session once per week.

Testing procedures

At baseline, 2 months, and 4 months, all participants were tested for strength, flexibility, exercise self-efficacy, depressive symptoms, and objectively measured PA. Body composition was assessed at baseline and 4 months. Each testing period included two visits to the Human Performance Laboratory (1 week apart). During the first laboratory visit at baseline, all participants completed an informed consent, PAR-Q, health history/demographic questionnaire, and an exercise self-efficacy and depressive symptoms questionnaire. Next, each participant completed a brief warm-up, followed by a standard sit-and-reach test for flexibility. Each participant was subsequently instructed on the proper lifting techniques for the leg press, bench press, and for the partial abdominal curl-up test and allowed to practice these exercises in order to minimize a possible learning effect. Also on the first visit, each subject was provided an Actigraph GT1M accelerometer (Actigraph LLC, Walton Beach, Florida, USA) and instructed to wear it continuously for the subsequent 7 days.

During the second laboratory visit, each accelerometer was collected and the data were downloaded for future analysis. Participants were then asked to change into a standardized, one-piece swimming suit and asked to void. Height and weight were then assessed, followed by body composition assessment using dual-energy x-ray absorptiometry (DXA) (Hologic, Bedford, Massachusetts, USA). After changing into athletic clothes and performing a brief warm-up, strength testing was completed for the upper body, lower body, and trunk. The exact same procedures were repeated at 2 and 4 months, except the DXA was repeated only at 4 months.

Strength assessment

Strength was assessed for the upper body (bench press), lower body (leg press), and trunk (partial abdominal curl-up test). A machine was used for both the bench press (Cybex, Owatonna, Minnesota, USA) and the leg press (Cybex). For the bench and leg press, a 3–5 repetition maximum (RM) test was used in place of a 1RM to reduce the likelihood of any adverse event (Niewiadomski et al., 2008).

The strength assessment protocol at each data collection period consisted of a brief warm-up. A starting weight was selected that was within 50–70% of the subjects estimated capacity to be lifted three to five times. Weight was then progressively increased until the subject could no longer lift the weight more than five times. The greatest amount of weight lifted successfully three to five times was used in the Brzycki equation to estimate 1RM. The Brzycki equation has been shown to be valid and reliable (Mayhew et al., 2008).

Each participant also completed the ACSM-recommended partial curl-up test with one modification (exclusion of a time limit), to assess abdominal strength and endurance at each period. In brief, each participant performed as many abdominal curl-ups as possible until she either stopped, or could not stay in rhythm with a cadence set at 40 beats/min.

Flexibility assessment

Flexibility was assessed at baseline, 2 months, and 4 months using the standard sit-and-reach test. After a brief warm-up, the standard sit-and-reach test was performed three times and the average score
A nationally standardized test and has been found to be valid (interclass correlation = 0.96; confidence interval = 0.94–0.97) (Hui & Yuen, 2000).

Adverse events

Participants were asked to immediately report the presence of any joint pain or out of the ordinary muscular pain to a member of the research staff.

Body composition assessment

Body weight was obtained using a digital scale (Tanita Corp., Tokyo, Japan) accurate to ±0.01 kg, with participants barefoot and wearing a standardized swimsuit. Height was measured using a stadiometer (Seca Corp., Chino, California, USA) and body mass index (BMI) was calculated as kg/m². DXA was used to assess fat mass, fat-free mass, body fat percentage, hip bone mineral density, and whole-body bone mineral density as it has been found to be both valid and reliable (Bailey et al., 2001; Maddalozzo et al., 2002).

Exercise self-efficacy

Exercise self-efficacy was measured using a short questionnaire developed by Marcus et al. (1992). This survey included five separate items each beginning with the stem, “I am confident I can participate in regular exercise when . . . .” followed by “I am tired,” “I am in a bad mood,” “I feel I don’t have the time,” “I am on vacation,” or “it is raining or snowing.” Respondent choices included, “Does not apply to me” or a scale of 1–11, with 1 being “not at all confident” and 11 being “very confident” (Marcus et al., 1992). Reported internal consistency (n = 917) was 0.82 and test–retest reliability over a duration of 2 weeks was 0.90 (n = 20) (Marcus et al., 1992).

Depressive symptoms

The Center for Epidemiological Studies Depression Scale (CES-D) was used to determine the presence of depressive symptoms for this study. According to this instrument, a score of 16 or greater indicates depression. The CES-D has an internal consistency of 0.82 and test–retest reliability of 0.61–0.62 (Beeghly et al., 2003) and is similar to the Edinburgh Postnatal Depression Scale for internal consistency and test–retest reliability (Boyd et al., 2005). Furthermore, the sensitivity and specificity of the CES-D is 60% and 92%, respectively (Campbell & Cohn, 1991), and has been previously used in a postpartum population (Wolfson et al., 2003; Surkan et al., 2012; Tandon et al., 2012).

Objectively measured physical activity

At baseline, 2 months, and 4 months, PA was assessed using an Actigraph GT1M accelerometer worn over the right hip for 7 consecutive days and set at 60-s epochs. To determine PA intensity, epoch cut-points from Troiano et al. were utilized and included the following: sedentary time = 249 counts/min or less; light-intensity activity time = 250–0027 counts/min; moderate-intensity time = 2020–5998 counts/min; vigorous-intensity activity = 5999 or greater counts/min; and MVPA was a sum of the moderate-intensity and vigorous-intensity time (Troiano et al., 2008). Accelerometers have been used in previous research and have been shown to be valid and reliable (Bassett et al., 2000). Participants were instructed to wear the accelerometer day and night (including while sleeping) and not to remove it except when in water (i.e. swimming or bathing).

Statistical analysis

For this study, the data were analyzed using PC-SAS (SAS Institute) with statistical significance set at P < 0.05. Standard deviations and means were used to summarize the descriptive and outcome data. Outcome variables were analyzed and primarily reported by completer-only analysis; however, intent-to-treat analyses are also reported in the Results section and in the tables of this study where pertinent. Independent t-tests were utilized to determine differences between groups at baseline. Mixed-effects models were utilized to determine differences in strength, flexibility, body composition, exercise self-efficacy, depressive symptoms, and PA outcomes within groups, and to test for the presence of a group × time interaction. We statistically controlled for the baseline score, number of months postpartum, and the number of children (parity) for each outcome variable reported in this study.

To analyze PA accelerometer data: (a) non-wear time was conservatively set as ≥20 min of continuous strings of zero counts; (b) a valid day was considered at least 12 h of wear time, or 75% wear time between the hours of 7 a.m. and 11 p.m.; however, all data for the entire 24-h period were used in the analyses; and (c) a valid week was considered at least 3 valid days (Massey et al., 2005). As a result of not meeting these criteria, one participant at baseline and 80 additional days (<8% of total data) were removed from analysis. Of note, one outlier in the FT group was removed from the PA analyses due to accelerometer malfunction.

Results

Participants were 90% Caucasian, 8.3% Hispanic, and 1.7% Asian, with 1.9 ± 1.2 children (45% primiparous and 55% multiparous), and most were breastfeeding at initiation of the study (95%). Among those that were breastfeeding, 56% were breastfeeding exclusively, 33% combined infant formula with breastfeeding, and 7% combined some solids with breastfeeding. The remaining two participants did not report the extent of breastfeeding combined with formula or solids. The mean number of months postpartum was 3.6 ± 1.6 for the RT group and 3.9 ± 1.8 for the FT group. Furthermore, ~46.7% of the participants were between 6 weeks and 3 months postpartum, ~41.7% were between 3 and 6 months postpartum, and ~11.7% were between 6 and 8 months postpartum. There was no difference in the baseline characteristics outlined in Table 1.

Forty-four participants completed the study. Table 2 shows the reasons for participant dropout in full. Of those who withdrew from the study, the mean time postpartum at baseline was 4.6 ± 2.0 months. Of the nine RT participants that withdrew (mean time postpartum = 3.7 ± 2.0 months), two were a result of injury that was not related to the study (one knee and one shoulder) and four others reported mild pain for at least 1 week (two knee and two shoulder) while completing the RT protocol, although pain was not cited as the reason for withdrawal. Of the 21 RT participants that completed the study, 5 reported some mild knee pain; however, in only one case was the knee pain reported to be persistent.
Resistance training in postpartum women

Table 1. Baseline participant characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>RT group</th>
<th>FT group</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 30</td>
<td>n = 30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>26.9 ± 5.1</td>
<td>25.9 ± 4.4</td>
<td>0.82</td>
<td>0.417</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.1 ± 3.7</td>
<td>27.0 ± 4.1</td>
<td>0.97</td>
<td>0.335</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>73.3 ± 11.4</td>
<td>72.0 ± 13.0</td>
<td>0.40</td>
<td>0.687</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>35.7 ± 5.4</td>
<td>37.0 ± 6.1</td>
<td>0.83</td>
<td>0.411</td>
</tr>
<tr>
<td>Pregnancy weight gain (kg)</td>
<td>16.1 ± 5.3</td>
<td>16.6 ± 4.5</td>
<td>0.04</td>
<td>0.967</td>
</tr>
<tr>
<td>Months postpartum</td>
<td>3.6 ± 1.6</td>
<td>3.9 ± 1.8</td>
<td>0.36</td>
<td>0.721</td>
</tr>
<tr>
<td>Weight retained postpartum (kg)</td>
<td>6.5 ± 3.7</td>
<td>6.5 ± 4.0</td>
<td>0.04</td>
<td>0.687</td>
</tr>
</tbody>
</table>

Values are mean ± standard deviation. F and P values represent differences between the RT and FT groups for all participants at baseline. BMI, body mass index; FT, flexibility training; RT, resistance training.

Table 2. Reasons for attrition by group

<table>
<thead>
<tr>
<th>Reasons for attrition</th>
<th>RT group</th>
<th>FT group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Loss of interest</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Withdrew after randomization</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Lack of time</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Moved from area</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>7</td>
<td>16</td>
</tr>
</tbody>
</table>

FT, flexibility training; RT, resistance training.

Beyond 1–2 weeks. For the FT group, one participant withdrew as a result of a shoulder pain experienced during initial strength testing. There were no other FT adverse events.

For the RT group completers, ~93% of the prescribed training sessions were completed. For FT group completers, ~80% of the prescribed training sessions were completed. Strength improved in both groups for the leg press (P < 0.05), bench press (P < 0.05), and abdominal curl-ups (P < 0.05). There was a significant group × time interaction for each strength outcome with the RT group improving to a greater extent than the FT group (P < 0.05) (Table 3). Flexibility scores for the sit-and-reach test improved in both groups (P < 0.05). However, the group × time interaction was not significant (F = 3.24, P = 0.079). Intent-to-treat analysis did not change the statistical significance of these results.

For completers, body composition and anthropometric measures generally improved for both the RT and the FT groups (P < 0.05). However, there was not a significant group × time interaction (P > 0.05) for BMI, body weight, fat mass, fat-free mass, body fat percentage, whole-body bone mineral density, or hip bone mineral density. Intent-to-treat analysis did not change the significance of these results (Table 4).

For completers, there was a significant group × time interaction for exercise self-efficacy (F = 5.33, P = 0.026), with the RT group exhibiting better exercise self-efficacy than the FT group, which remained when intent-to-treat analysis was utilized (F = 4.27; P = 0.045). In addition, for the RT completers, there was a significant decrease in their CES-D score from baseline (9.5 ± 6.3) to 4 months (6.4 ± 4.1) (F = 4.61, P = 0.016). There was no change in CES-D score in the FT group (F = 1.13, P = 0.332). However, the group × time interaction in CES-D score did not reach significance (F = 1.33, P = 0.255). Intent-to-treat analysis revealed that the group × time interaction for CES-D score remained non-significant (F = 2.81, P = 0.101).

The group × time interaction for total activity did not reach significance (F = 3.53, P = 0.068) for completers, as shown in Table 4. Among completers, there was a significant group × time interaction for sedentary time (F = 5.27, P = 0.027) and light-intensity activity time (F = 5.55, P = 0.023), with the RT group showing greater improvements than the FT group for both. There was not a significant group × time interaction for moderate-intensity, vigorous-intensity PA, or MVPA time (P > 0.05). Intent-to-treat analyses did not significantly influence these results.

Discussion

In the Consensus Statement entitled, “Impact of Physical Activity during Pregnancy and Postpartum on Chronic Disease,” it was noted that among the Healthy People 2010 Leading Health Indicators, that “…increasing physical activity and reducing obesity are the greatest priorities for enhancing women’s health” (Pivarnik et al., 2006). The present study addressed the above indicators by examining PA and obesity-related outcomes associated with RT. This study suggests that RT increases strength and may be associated with better exercise self-efficacy and more positive PA changes compared to FT in postpartum women; however, body composition and depressive symptom changes were not statistically different between groups over time. Several observations follow.
Table 3. Differences in strength and flexibility between the RT and FT groups across time

<table>
<thead>
<tr>
<th>Variable</th>
<th>RT group</th>
<th>FT group</th>
<th>F</th>
<th>P*</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 21</td>
<td>n = 23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baseline 2 months</td>
<td>Baseline 2 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bench press (kg)</td>
<td>26.8 ± 6.1</td>
<td>31.5 ± 6.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg press (kg)</td>
<td>80.9 ± 15.1</td>
<td>95.4 ± 16.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdominal curl-ups</td>
<td>36.8 ± 20.6</td>
<td>70.7 ± 50.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sit-and-reach (cm)</td>
<td>30.0 ± 9.1</td>
<td>32.2 ± 7.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values are mean ± standard deviation. There were no baseline differences to report.

Strength outcomes represent estimated 1 repetition maximum (1RM).

*Significant (P < 0.05) within group change over the duration of the study. Both groups improved in each outcome.

F and P = Group × time interaction for completers (n = 44) with control of baseline, time postpartum, and parity.

P* = Intent-to-treat analysis (n = 60). Group × time interaction with control of baseline, time postpartum, and parity.

FT, flexibility training; RT, resistance training.

As previously noted, there are few studies that have examined RT in postpartum women. However, there has been one recent study that compared 16 weeks of combined strength (3 days/week) and aerobic training to a control group in 20 subjects (Lovelady et al., 2009). A comparison of the present study and the Lovelady et al.’s study showed significant improvements in strength outcomes due to resistance training, respectively (36% and 63% increase in bench press; 31% increase in leg press and 46% increase in squats; 228% increase in abdominal curl-ups and 128% increase in abdominal crunches) (Lovelady et al., 2009). Furthermore, in both studies, the intervention and control groups decreased in most body composition outcomes measured; however, the lean body mass loss was significantly attenuated in the intervention group of the Lovelady et al.’s study (Lovelady et al., 2009), while there was no difference in fat-free mass between groups in the present study. Taken together, these data suggest that strength is improved with RT in a postpartum sample of women, yet 3 days of RT per week may be more beneficial than 2 days to increase strength and attenuate loss in fat-free mass.

In the present study, 27% of all RT participants reported mild pain while training (four non-completers and five completers). In six out of nine cases, the culprit was knee pain during the leg extension exercise. This should be considered when prescribing RT in this population.

There was a noted group × time interaction for overall exercise self-efficacy. Two specific constructs were most important, including the questions about: (a) confidence in ability to exercise when tired, and (b) confidence in ability to exercise when in a bad mood. Over the duration of the study, RT was associated with a 7.1% improvement in ability to exercise when tired, while the FT group saw a 9.1% decrease, or a 16.2% total difference (F = 6.51, P = 0.015). Similarly, RT was associated with a 4.3% improvement in ability to exercise when in a bad mood, while the FT group saw a 5.8% decrease, or a 10.1% difference (F = 8.27, P = 0.006). The difference in exercise self-efficacy may be due to the supervised training the RT participants received; whereas the FT group did their training on their own. We are encouraged by this finding, but the long-term implications for RT recommendations and programming need further investigation.

Although there was not a significant group × time interaction in CES-D scores, there are several noteworthy trends. First, within group analysis showed that the RT group significantly reduced their depressive symptoms while the FT group did not. Second, 10 participants were classified as depressed at baseline (RT = 4, FT = 6) according to the CES-D (≥16). Each RT participant (n = 4) was no longer considered depressed by the end of the study (CES-D < 16), but only 50% (n = 3/6) of the FT group were no longer depressed by the end of the study. Third, 18 study completers showed depressive symptoms (CES-D score ≥10) at baseline. A total of 88% (seven out of eight) of RT participants resolved their depressive symptoms, whereas only 50% (5 out of 10) of the FT participants resolved their depressive symptoms. These trends suggest that additional investigation of the role of RT for depressive symptoms is warranted.

Sedentary time and light-intensity PA time improved to a greater extent in the RT group than the FT group. We originally anticipated that PA changes would be stronger in the RT group for several possible reasons. First, RT would lead to greater strength and, therefore, greater ease of spontaneous activity and movement. Second, RT would result in improved confidence to perform PA following childbirth and perhaps facilitate behavioral change toward a sustained increase in spontaneous PA (Schmitz et al., 2003). Third, the actual RT intervention and training sessions themselves would result in more PA.

It is unclear which of the above explained the significant difference in sedentary and light-intensity time. Interestingly, sedentary time was reduced in the RT group by 22 min/day (154 min/week) vs 9 min/day (63 min/week) in the FT group. Similarly, light-activity
Table 4. Body composition and physical activity measures between groups across time

<table>
<thead>
<tr>
<th>Variable</th>
<th>RT group</th>
<th>FT group</th>
<th>F</th>
<th>P†</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 21</td>
<td>n = 23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baseline</td>
<td>2 months</td>
<td>4 months</td>
<td>Baseline</td>
<td>2 months</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.0 ± 3.4</td>
<td>24.6 ± 3.5</td>
<td>24.0 ± 3.5*</td>
<td>27.1 ± 3.9</td>
<td>26.6 ± 4.2</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>70.6 ± 10.5</td>
<td>69.2 ± 10.5</td>
<td>67.8 ± 10.7*</td>
<td>72.1 ± 13.2</td>
<td>70.6 ± 13.6</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>23.2 ± 6.9</td>
<td>ND</td>
<td>20.7 ± 6.7*</td>
<td>25.2 ± 7.7</td>
<td>ND</td>
</tr>
<tr>
<td>Fat free mass (kg)</td>
<td>40.2 ± 4.4</td>
<td>ND</td>
<td>40.3 ± 4.7</td>
<td>39.8 ± 6.0</td>
<td>ND</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>35.0 ± 5.4</td>
<td>ND</td>
<td>32.3 ± 5.5*</td>
<td>37.2 ± 5.9</td>
<td>ND</td>
</tr>
<tr>
<td>Whole BMD (g/cm²)</td>
<td>1.13 ± 0.06</td>
<td>ND</td>
<td>1.13 ± 0.06</td>
<td>1.14 ± 0.07</td>
<td>ND</td>
</tr>
<tr>
<td>Hip BMD (g/cm²)</td>
<td>0.96 ± 0.10</td>
<td>ND</td>
<td>0.94 ± 0.10</td>
<td>0.95 ± 0.11</td>
<td>ND</td>
</tr>
<tr>
<td>Counts/day</td>
<td>215 908 ± 48 222</td>
<td>238 113 ± 64 120</td>
<td>252 172 ± 82 975*</td>
<td>239 665 ± 68 159</td>
<td>257 067 ± 61 727</td>
</tr>
<tr>
<td>Sedentary time</td>
<td>1210 ± 44</td>
<td>1201 ± 42</td>
<td>1188 ± 47*</td>
<td>1191 ± 57</td>
<td>1171 ± 47</td>
</tr>
<tr>
<td>Light activity</td>
<td>214 ± 44</td>
<td>221 ± 42</td>
<td>234 ± 42*</td>
<td>234 ± 55</td>
<td>250 ± 45</td>
</tr>
<tr>
<td>Moderate activity</td>
<td>15 ± 10</td>
<td>15 ± 10</td>
<td>15 ± 11</td>
<td>14 ± 8</td>
<td>17 ± 10</td>
</tr>
<tr>
<td>Vigorous activity</td>
<td>1 ± 1</td>
<td>2 ± 4</td>
<td>3 ± 6</td>
<td>2 ± 3</td>
<td>1 ± 2</td>
</tr>
<tr>
<td>MVPA</td>
<td>15 ± 11</td>
<td>17 ± 12</td>
<td>18 ± 13</td>
<td>15 ± 11</td>
<td>19 ± 11</td>
</tr>
</tbody>
</table>

Values are mean ± standard deviation. There were no baseline differences to report.

Counts/day represents the average total counts per day. Data for sedentary, light-, moderate-, vigorous-intensity time, and MVPA represent min/day.

* Significant (P<0.05) within group change over the duration of the study.

F and P† = Group × time interaction for completers (n = 44) with control of baseline, time postpartum, and parity.

P* = Intent-to-treat analysis (n = 60). Group × time interaction with control of baseline, time postpartum, and parity.

One outlier in the FT group was removed from the physical activity analyses due to spurious accelerometer data.

BMI, body mass index; BMD, bone mineral density; FT, flexibility training; MVPA, moderate to vigorous physical activity; ND, no data; RT, resistance training.
time was increased by 20 min/day (140 min/week) in the RT group and 8 min/day (56 min/week) in the FT group. Given these data, a large portion of the difference is likely a result of movement during the RT or FT sessions themselves. Regardless, a decrease in sedentary time may be a worthy public health message in and of itself as a sedentary lifestyle is associated with increased health risks (Leitzmann et al., 2007).

This study had significant strengths including application of a RT intervention not well-examined in postpartum women, and objective measures of strength, body composition, and physical activity. However, the notable limitation of this study is the modest sample size. In addition, exercise self-efficacy and depressive symptom changes were reported because they have not been previously described in relation to postpartum RT, although this study was not powered for those outcomes.

**Perspective**

Insufficient PA is among the primary health concerns for women. Postpartum may be a particularly high risk period for insufficient PA. The results of this study indicate that twice-weekly RT has positive benefits in postpartum women, including an improvement in some PA outcomes. Furthermore, there may be public and clinical health benefits of RT beyond the strength increases traditionally reported in other non-postpartum adult studies. Therefore, this study suggests that twice-weekly RT may be beneficial for postpartum women. Nevertheless, it is important to recognize the potential difficulty that may exist for postpartum women to consistently perform RT and PA that have significant time barriers, such as single mothers, mothers with special needs children, or mothers returning to the workforce. Future studies are needed to effectively increase PA levels and RT long term in postpartum women.

**Key words:** childbirth, weight training, strength training, exercise, physical activity, women’s health, obesity.

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