Regional Fat Changes Induced by Localized Muscle Endurance Resistance Training

Article in The Journal of Strength and Conditioning Research - August 2013
DOI: 10.1519/JSC.0b013e31827e8681 · Source: PubMed

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REGIONAL FAT CHANGES INDUCED BY LOCALIZED MUSCLE ENDURANCE RESISTANCE TRAINING

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1Physical Activity Sciences Department, Los Lagos University, Osorno, Chile; 2Celular Physiology Laboratory, Biomedical Department, Faculty of Health Sciences, Autónoma University, Autónoma, Chile; 3Kinesiology Department, Los Lagos University, Puerto Montt, Chile; 4Physiology Laboratory, Biological Sciences Department, Biological Sciences Faculty, Andres Bello University, Santiago, Chile; 5Los Lagos Family Health Center, Health Promotion Center for Women, Los Lagos, Chile; and 6Department of Health Sciences, Public University of Navarre, Tudela, Spain

ABSTRACT

Ramírez-Campillo, R, Andrade, DC, Campos-Jara, C, Henríquez-Olguín, C, Álvarez-Lepin, C, and Izquierdo, M. Regional fat changes induced by localized muscle endurance resistance training. J Strength Cond Res 27(8): 2219–2224, 2013—The purpose of this study was to examine the effects of a localized muscle endurance resistance training program on total body and regional tissue composition. Seven men and 4 women (aged 23 ± 1 years) were trained with their nondominant leg during 12 weeks, 3 sessions per week. Each session consisted of 1 set of 960–1,200 repetitions (leg press exercise), at 10–30% 1 repetition maximum. Before and after training, body mass, bone mass, bone mineral density (BMD), lean mass, fat mass, and fat percentage were determined by dual-emission x-ray absorptiometry. Energy intakes were registered using a food recall questionnaire. At the whole-body level, body mass, bone mass, BMD, lean mass, or body fat percentage were not significantly changed. However, body fat mass significantly decreased by 5.1% (preexercise: 13.5 ± 6.3 kg; postexercise: 12.8 ± 5.4 kg, p < 0.05). No significant changes in bone mass, lean mass, fat mass, or fat percentage were observed in both the control and trained leg. A significant (p < 0.05) decrease in fat mass was observed in the upper extremities and trunk (10.2 and 6.9%, respectively, p < 0.05). The reduction of fat mass in the upper extremities and trunk was significantly greater (p < 0.05) than the fat mass change observed in the trained leg but not in the control leg. No significant changes were observed in energy intake pre- and postexercise intervention (2,646 ± 444 kcal·d⁻¹ and 2,677 ± 617 kcal·d⁻¹, respectively). In conclusion, the training program was effective in reducing fat mass, but this reduction was not achieved in the trained body segment. The present results expand the limited knowledge available about the plastic heterogeneity of regional body tissues when a localized resistance training program is applied.

KEY WORDS spot reduction, DXA, corporal composition, exercise

INTRODUCTION

Exercise programs (aerobic or resistance training) may lead to differential regional adipose tissue depot loss, possibly by differential regional alterations of adipose tissue depot metabolism (i.e., mobilization of free fatty acids) (8). Several studies have shown that exercise-induced relative loss of fat seems to be higher in the abdominal region (16) or in the arms (17) than in the femoral region. This suggests that training-induced adipose tissue depot changes differ between body regions. Indeed, whether specific exercises can reduce local adipose tissue depots and thus modify fat distribution is still open to discussion.

The term spot reduction refers to the localized loss of fat as a result of exercising a particular part of the body (10). Several studies have evaluated the effects of specific localized exercise on whole-body and regional tissue composition, with contradicting results. Some studies have reported that after exercise intervention, localized mobilization of subcutaneous fat may be observed (15,18,19,21), whereas others have not found these changes (6,9,10,12,17,23). The conflicting results may be accounted for by the methodology used in the studies cited. A valid study design to test the hypothesis of spot reduction would be one in which the muscles in one part of the body are trained, whereas the muscles in the contralateral side are not. In addition, the size of the adipose tissue depots adjacent to the trained and respective sedentary muscles should be carefully monitored before and after the intervention period (21) using valid measurement techniques, such as fat biopsy, dual-emission x-ray absorptiometry (DXA), or magnetic resonance image techniques (10). Some of the previous studies cited met these criteria (10,12); nevertheless, because of the training protocol used (i.e., low training volume), localized blood flow and...
localized muscle endurance resistance training program on body tissue composition. To this end, a group of 11 subjects volunteered to participate in the study. Anthropometric tests were carried out to establish a baseline. After the initial measurements, subjects were enrolled in 12 weeks of training. Before initiating the training period, the subjects were instructed on how to properly execute the exercise to be done during this period. The training protocol only included the leg press exercise. None of the subjects had performed regular resistance training previously. All training sessions were supervised. The subjects were instructed to maintain their usual physical activity during the experimental period and to maintain their dietary habits for the duration of the study.

Methods
Experimental Approach to the Problem
This study was designed to address the question of how 12 weeks of a localized muscle endurance resistance training program for the nondominant leg affects local and regional body tissue composition. To this end, a group of 11 subjects were recruited. Anthropometric tests were carried out to establish a baseline. After the initial measurements, subjects were enrolled in 12 weeks of training. Before initiating the training period, the subjects were instructed on how to properly execute the exercise to be done during this period. The training protocol only included the leg press exercise. None of the subjects had performed regular resistance training previously. All training sessions were supervised. The subjects were instructed to maintain their usual physical activity during the experimental period and to maintain their dietary habits for the duration of the study.

Subjects
Eleven physical education students (7 men and 4 women), with an average age (±SD) of 23 ± 1 years and body mass index of 25 ± 2 kg m⁻², volunteered to participate in the study (more detailed initial anthropometric characteristics are given in Table 1). All subjects were carefully informed about the experimental procedures and about the possible risks and benefits associated with participation in the study and signed an informed consent document before any of the tests were performed. The study was conducted in accordance with the Declaration of Helsinki and was approved by the ethics committee of the department responsible. All subjects who took part in the training program (nondominant leg) served as their own control (dominant leg). Sample size was computed according to changes observed in fat mass percentage ($\bar{d} = 9.8\%$; $SD = 10.9$) in a group of subjects submitted to training for 14 weeks (17).

A total of 11 participants per group would yield a power of 80% and a $\alpha$ of 0.05.

None of the members participated in any formal exercise programs. Before the training program, there were no significant differences between the experimental and control leg in any of the dependent study variables. The general experimental procedure was a pre- and posttest design.

Anthropometric Characteristics and Testing Procedures
Total body and regional estimates of bone mass, bone mineral density (BMD), fat mass, lean mass, and fat percentage were determined by DXA using manufacturer-supplied algorithms (Total Body Analysis, version 3.6; Lunar, Madison, WI, USA). Precision for this measurement is greater than ±0.5% for body fat. For this procedure, the subjects dressed in underwear and lay face-up on a DXA scanner table. The body was carefully positioned so that it was laterally centered on the table with hands palm downward. Velcro straps were used to keep the knees together and support the feet so that they tilted 45° from the vertical. Scanning was in 1-cm slices from head to toe using a 20-minute scanning speed. Regional measurements (arm, leg, and trunk) were determined on the basis of bony landmarks via manual analysis. The boundary between the arms and trunk was vertical (at shoulder level), whereas the boundary between the legs and trunk was angled. The precision of the measurement reported in these 3 regions is 1.5, 0.8, and 1.1% for the arms, legs, and trunk, respectively (17). Dual-emission x-ray absorptiometry measurements for total body and regional tissue composition were obtained before the study began (pre) and the day after the training period. The intraclass correlation coefficient was 0.97 (0.96–0.98) for arm fat, 0.97 (0.96–0.98) for leg fat, and 0.97 (0.96–0.98) for trunk fat.

Treatment
Subjects completed a 12-week localized muscle endurance resistance training program for the leg muscles of their nondominant leg. Training sessions were performed 3 d·wk⁻¹. Each session lasted 80 minutes. Subjects completed one set of one exercise (i.e., leg press) per session, at 10–30% of 1 repetition maximum (IRM) (10% during weeks 1–4, 20% during weeks 5–6, and 30% during weeks 7–12). Subjects completed 960–1,200 consecutive repetitions for their set (no rest between repetitions), with 4–5 seconds per repetition (if subjects could not maintain the established rate of muscular work, weight was reduced), for a total of 80 minutes of continuous leg press exercise. During training, subjects completed a very high training volume, reaching a total of 34,560–43,200 muscle contractions in 12 weeks, a volume 10 times greater than that used in studies by other authors (23) that examined the impact of a localized muscle endurance resistance training program on body tissue composition. This high volume of training was necessary to induce important energy expenditure, with the objective of altering body tissue composition. During each training session, subjects were recommended to maintain...
their habitual physical activity routine throughout the experiment.

**Energy and Macronutrient Intake.** Energy and macronutrient intake was determined before and after intervention. An experienced nutritionist performed the energy intake analysis using a food recall questionnaire. The questionnaire was completed on 3 different days (Monday, Tuesday, and Sunday). Subjects were instructed not to change their eating habits during the intervention period; this was controlled by weekly interviews between the lead researcher and the subjects. Food analyses were carried out with the online software MITABLA (MITABLA software v4.0, Santiago, Chile).

**Statistical Analyses**
Statistical analyses were performed using STATISTICA software (version 8.0; StatSoft, Inc., Tulsa, OK, USA). Normality and homoscedasticity assumptions for all data were checked, respectively, with Shapiro-Wilk and Levene tests. A repeated-measures analysis of variance was used to determine differences in all dependent variables. There were 2 levels of repeated measures (pre- and posttraining periods). A Sheffe post hoc follow-up test was used when significance was detected. An α level of 0.05 was used for all statistics.

**RESULTS**

**Total Body Composition**
Significant (p ≤ 0.05) decreases were observed in total body fat, whereas no significant changes were observed in total body mass, BMD, bone mass, or fat percentage (Table 1). A neutral/positive nitrogen balance was evidenced by the maintenance of total lean mass (Table 1).

**Trunk Region and Arms**
After localized training intervention, fat mass of the trunk region and arms was significantly (p < 0.05) reduced (Table 1). In contrast, no significant changes were observed in bone mass, lean mass, or fat percentage of the trunk region and arms (Table 1).

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**Table 1.** Dual-emission x-ray absorptiometry-assessed changes in total body and regional tissue composition over a 12-week localized muscle endurance resistance training program.*

<table>
<thead>
<tr>
<th>Body region</th>
<th>Before</th>
<th>After</th>
<th>Before and after percentage change</th>
<th>Effect sizes (ηp²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total body</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass, kg</td>
<td>65.55 ± 5.7</td>
<td>64.59 ± 6.6</td>
<td>-1.5</td>
<td>0.091</td>
</tr>
<tr>
<td>Bone mineral density, g cm⁻²</td>
<td>1.20 ± 0.1</td>
<td>1.20 ± 0.1</td>
<td>0</td>
<td>0.011</td>
</tr>
<tr>
<td>Bone mass, kg</td>
<td>2.78 ± 0.5</td>
<td>2.73 ± 0.5</td>
<td>-1.8</td>
<td>0.406</td>
</tr>
<tr>
<td>Lean mass, kg</td>
<td>48.64 ± 9.3</td>
<td>48.64 ± 9.1</td>
<td>0</td>
<td>0.00001</td>
</tr>
<tr>
<td>Fat mass, kg</td>
<td>13.51 ± 6.3</td>
<td>12.82 ± 5.4</td>
<td>-5.1</td>
<td>0.027</td>
</tr>
<tr>
<td>%Fat</td>
<td>21.74 ± 10.7</td>
<td>20.88 ± 9.1</td>
<td>-0.9</td>
<td>0.089</td>
</tr>
<tr>
<td>Trunk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone mass, kg</td>
<td>0.93 ± 0.1</td>
<td>0.89 ± 0.1</td>
<td>-4.3</td>
<td>0.379</td>
</tr>
<tr>
<td>Lean mass, kg</td>
<td>22.72 ± 4.0</td>
<td>22.65 ± 3.6</td>
<td>-0.3</td>
<td>0.005</td>
</tr>
<tr>
<td>Fat mass, kg</td>
<td>7.24 ± 3.6</td>
<td>6.72 ± 3.1</td>
<td>-7.2</td>
<td>0.060</td>
</tr>
<tr>
<td>%Fat</td>
<td>24.19 ± 11.4</td>
<td>22.71 ± 9.2</td>
<td>-1.5</td>
<td>0.115</td>
</tr>
<tr>
<td>Control leg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone mass, kg</td>
<td>0.54 ± 0.1</td>
<td>0.53 ± 0.1</td>
<td>-1.9%</td>
<td>0.434</td>
</tr>
<tr>
<td>Lean mass, kg</td>
<td>9.20 ± 1.5</td>
<td>8.87 ± 1.7</td>
<td>-3.6</td>
<td>0.152</td>
</tr>
<tr>
<td>Fat mass, kg</td>
<td>2.43 ± 1.2</td>
<td>2.36 ± 1.1</td>
<td>-2.9</td>
<td>0.004</td>
</tr>
<tr>
<td>%Fat</td>
<td>20.48 ± 7.4</td>
<td>19.94 ± 6.1</td>
<td>-0.5</td>
<td>0.024</td>
</tr>
<tr>
<td>Trained leg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone mass, kg</td>
<td>0.53 ± 0.1</td>
<td>0.53 ± 0.1</td>
<td>0</td>
<td>0.476</td>
</tr>
<tr>
<td>Lean mass, kg</td>
<td>9.16 ± 1.5</td>
<td>9.03 ± 1.9</td>
<td>-1.4</td>
<td>0.032</td>
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<tr>
<td>Fat mass, kg</td>
<td>2.41 ± 1.1</td>
<td>2.39 ± 1.0</td>
<td>-0.8%</td>
<td>0.014</td>
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<tr>
<td>%Fat</td>
<td>20.48 ± 7.4</td>
<td>19.94 ± 6.1</td>
<td>-0.5</td>
<td>0.024</td>
</tr>
<tr>
<td>Arms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone mass, kg</td>
<td>0.17 ± 0.03</td>
<td>0.17 ± 0.03</td>
<td>0</td>
<td>0.0007</td>
</tr>
<tr>
<td>Lean mass, kg</td>
<td>2.80 ± 0.6</td>
<td>2.73 ± 0.7</td>
<td>-2.5</td>
<td>0.083</td>
</tr>
<tr>
<td>Fat mass, kg</td>
<td>0.49 ± 0.2</td>
<td>0.44 ± 0.2</td>
<td>-10.2</td>
<td>0.019</td>
</tr>
<tr>
<td>%Fat</td>
<td>16.43 ± 9.5</td>
<td>15.65 ± 8.7</td>
<td>-0.8</td>
<td>0.002</td>
</tr>
</tbody>
</table>

*Values are mean ± SD.
†Statistically significant (p ≤ 0.05) difference between pre- and postintervention.
‡Statistically significant (p ≤ 0.05) difference vs. arms and trunk.
Localized Resistance Training and Fat Changes

**Trained and Control Leg**

After the intervention, neither the trained nor the control legs exhibit significant changes in bone mass, lean mass, fat mass, or fat percentage (Table 1). The fat mass reduction in arms and trunk region was significantly higher than that observed in the trained leg but not in the control leg (Table 1).

**Energy and Macronutrient Intake**

No significant change in energy intake (preexercise: 2,782 ± 306 kcal·d⁻¹; postexercise: 2,677 ± 617 kcal·d⁻¹) or macronutrient distribution ([carbohydrate, pre: 393 ± 93 g·d⁻¹; post: 378 ± 104 g·d⁻¹] [protein, pre: 93 ± 23 g·d⁻¹; post: 83 ± 30 g·d⁻¹] [fat, pre: 94 ± 23 g·d⁻¹; post: 92 ± 29 g·d⁻¹]) was evident over the 12-week intervention period.

**DISCUSSION**

To the best of our knowledge, the unique approach of the present study was to examine, with a valid anthropometric technique such as DXA (10), training-induced changes in lean mass, fat mass, and bone mass in total body, legs, arms, and trunk after a localized muscle endurance resistance training program of relatively high training volume (i.e., 34,560–43,200 muscle contractions). Furthermore, this unique approach included examining possible training-induced spot reduction while the subjects' energy intake was carefully controlled. The main finding of the present study showed that localized muscle endurance resistance training induces significant training-related decreases in the trunk, arms, and total body adipose tissue depots, whereas tissue composition (i.e., bone mass, lean mass, fat mass, and %fat) of the trained and untrained legs remained unchanged. These results may highlight the importance of evaluating whole-body tissue composition changes (not only localized) when this type of resistance training is executed.

An interesting finding of the present study was that after localized training intervention, the lower extremities do not experience a significant reduction in fat mass. These results do not support a localized effect of resistance training on the fat mass content of a body segment (spot reduction). Our results agree with those of Gwinup et al. (6), showing an increased arm girth of the dominant arm vs. nondominant arm in competitive tennis players, whereas subcutaneous fat folds thickness remained similar between segments. Similarly, Krotkiewski et al. (12) showed that 5 weeks of training for the right leg (i.e., 30 maximal isokinetic leg extensions per session) resulted in muscle hypertrophy for the trained leg, in combination with a reduced subcutaneous fat thickness, whereas adipose cell size did not show a significant reduction. In this study, it was argued that geometric factors, secondary to muscle hypertrophy, may explain the reduction in subcutaneous fat thickness. In another study, 27 days of abdominal training did not induce a localized fat mobilization from the abdominal area (9). Nindl et al. (17) also showed that military training (focused primarily on legs) induced a significant increase in leg lean mass (5.5%), whereas fat mass was reduced only in arms and trunk region. Finally, 3 months of heavy resistance training of the non-dominant arm in 104 subjects (10) resulted in a significant increase in muscle volume in the trained arm, but subcutaneous fat volume did not change. On the other hand, other authors reported that 30–120 minutes of unilateral knee
extension exercise induced a higher adipose tissue blood flow in the exercise leg vs. the control leg (21), but this localized (blood flow) effect is not supported by other studies (3,4). Therefore, our results, in accordance with the previous studies undertaken, do not support a localized effect of resistance training on the fat mass content of a body segment (spot reduction).

Although other studies show a significant increase in lean mass after a localized resistance training program (10,12), our results did not show a significant change in lean mass in the trained leg (−1.1%) or in other body parts. The difference between our results and those reported by other authors may be related to the training methodology used. We used a muscle endurance resistance training protocol with a very high volume and very low intensity (960–1,200 muscle contractions per training session, with 10–30% 1RM), whereas other studies (10,12) used a relatively low-volume and high-intensity resistance training protocol (75–100% of maximum strength). Thus, minimum threshold intensity may be required to induce muscle and hypertrophy adaptations (11). It is also possible that, although the resistance used in the present investigation did not achieve the necessary threshold intensity to induce changes in lean mass, it was sufficient to induce a significant increase in energy expenditure and modification of fat mass. An alternative explanation may derive from the sex of the subjects. Women, in comparison with men, may not exhibit the same lean mass change after a resistance training program (10) or may need longer adaptation periods to exhibit muscular hypertrophy (17). Twenty-five percent of the subjects in this study were women, which when compared with the previously cited studies may also help explain why the lean mass of the trained leg did not increase significantly. Future studies may complement a localized muscle endurance resistance training program with high-intensity resistance training (or include preferentially male subjects), if an increase in lean mass is important to verify the investigation hypothesis.

In conclusion, the training program applied effectively reduced fat mass, but this reduction was not achieved in the trained body segment. The total training load (resistance × time) used during training was optimal to induce considerable fat mass loss but did not result in a significant muscle hypertrophy. Our results expand the limited knowledge available with regard to the plastic heterogeneity of regional body tissues when a localized resistance training program is applied.

**Practical Applications**

Our results show that when a muscle group is trained, changes in fat mass may take place in body areas not necessarily adjacent to the trained muscle group. Therefore, trunk body fat may be modified by training arm or leg muscles. This may be very useful in rehabilitation settings, where subjects, using their able body segment, may favorably impact the fat content in any other body part.

The present results also suggest that muscle endurance resistance training of 80 minutes per session did not result in significant muscle hypertrophy. Higher resistance will be required to induce changes in muscle mass (12). On the other hand, a training methodology, similar to that used in our study, may be sufficient to achieve a reduction in fat mass, but we recommend muscle endurance resistance training programs that include big muscle groups, which may result in more time efficient energy expenditure and corporal composition modification.

**Acknowledgments**

The authors disclose professional relationships with companies or manufacturers who will benefit from the results of this study. The results of this study do not constitute endorsement of the product by the authors of the National Strength and Conditioning Association. The authors disclose that funding was received for this work from the following organizations: National Institutes of Health, Welcome Trust, Howard Hughes Medical Institute, and other(s).

**References**

Localized Resistance Training and Fat Changes


