The Effect of Abdominal Exercise on Abdominal Fat

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Abstract

Vispute, SS, Smith, JD, LeCheminant, JD, and Hurley, KS. The effect of abdominal exercise on abdominal fat. *J Strength Cond Res* 25(9): 2559–2564, 2011—The purpose of this study was to investigate the effect of abdominal exercises on abdominal fat. Twenty-four healthy, sedentary participants (14 men and 10 women), between 18 and 40 years, were randomly assigned to 1 of the following 2 groups: control group (CG) or abdominal exercise group (AG). Anthropometrics, body composition, and abdominal muscular endurance were tested before and after training. The AG performed 7 abdominal exercises, for 2 sets of 10 repetitions, on 5 $d \cdot wk^{-1}$ for 6 weeks. The CG received no intervention, and all participants maintained an isocaloric diet throughout the study. Significance was set at $p = 0.05$ for all tests. There was no significant effect of abdominal exercises on body weight, body fat percentage, android fat percentage, android fat, abdominal circumference, abdominal skinfold and suprailiac skinfold measurements. The AG performed significantly greater amount of curl-up repetitions (47 ± 13) compared to the CG (32 ± 9) on the posttest. Six weeks of abdominal exercise training alone was not sufficient to reduce abdominal subcutaneous fat and other measures of body composition. Nevertheless, abdominal exercise training significantly improved muscular endurance to a greater extent than the CG.

Key Words subcutaneous fat, body composition, muscular endurance

Introduction

In the past 2 decades, overweight and obesity have significantly increased in most industrialized nations (11). Abdominal obesity tends to increase with weight gain and is strongly associated with various diseases such as coronary heart disease and type 2 diabetes mellitus (18). In addition, abdominal obesity is associated with increased levels of visceral fat. This appears partially responsible for metabolic complications such as insulin resistance, glucose intolerance, high total and low-density lipoprotein cholesterol, low high-density lipoprotein cholesterol, and the metabolic syndrome (1,18,20). However, a reduction in visceral fat tends to reduce these complications thereby decreasing the risk for coronary heart disease (23).

Exercise is one of the most important and common components of weight loss and weight management programs. Aerobic exercise has been shown to increase the likelihood of body weight maintenance (4,5,9). Progressive resistance training has been shown to be effective in decreasing abdominal subcutaneous and visceral fat, even without changes in body weight (7,23). Further, there is evidence that exercise may have the benefit of keeping the waistline trim by significantly reducing total abdominal, abdominal subcutaneous, and visceral fat (23). Other researchers have shown a loss of total abdominal, abdominal subcutaneous and visceral fat after aerobic and progressive resistance training (6,17).

Abdominal exercises, such as core conditioning exercises, are often promoted as an effective means to reduce abdominal fat and trim the waistline. Because previous support for "spot reduction" in body fat is mixed (10,14,15,19) and generally not considered valid without creating a consistent energy deficit (10), it is questionable whether or not abdominal exercises alone are sufficient to produce abdominal fat loss. Further, as noted by Kostek et al. (12), most studies investigating "spot reduction" have used skinfolds to measure subcutaneous fat. The limitations of the skinfold technique are well known, and the results tend to vary according to age, sex, distribution of fat, and measurement technique (13). Nevertheless, there is some evidence that abdominal exercises can influence fat cell size. Katch et al. examined fat cell size of adipose tissue after biopsy to investigate the effect of exercise on subcutaneous adipose tissue (10). After randomizing 19 young Caucasian men to an exercise or a control group (CG) for 4 weeks, these researchers

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demonstrated that a progressive sit-up exercise program can cause a significant reduction in fat cell size of the abdominal, subscapular, and gluteal region (10). Although there was no preferential use of subcutaneous fat over the abdominal region, 4 weeks of abdominal exercise was sufficient to cause reductions in fat cell size (10).

Although abdominal exercises may potentially improve the strength and endurance of abdominal muscles, the extent to which these exercises influence abdominal fat warrants further investigation. Therefore, the primary purpose of this study was to examine the effect of 6 weeks of abdominal exercises on abdominal fat in young adults.

Methods

Experimental Approach to the Problem

An experimental, randomized-controlled design was used to assess the effect of abdominal exercises on changes in abdominal fat, waist circumference, and abdominal strength. Subjects were randomly assigned to an abdominal exercise group (AG) or a CG. The AG performed 7 abdominal exercises, each with 2 sets of 10 repetitions, on 5 $d \cdot wk^{-1}$ for 6 weeks. The CG maintained their normal activities of daily living (ADL). Anthropometrics, body composition, and abdominal muscular endurance were assessed at baseline and after 6 weeks in both groups.

Subjects

This study was approved by Southern Illinois University's Institutional Review Board. Participants were recruited via fliers, email, and word of mouth among the Southern Illinois University Edwardsville (SIUE) students. Twenty-four healthy sedentary participants (Table 1) agreed to participate, and appropriate informed consent was obtained from each participant before initiation of the study. Those who were physically active >20 minutes a day twice a week, were smokers, had gained or lost >2.2 kg in the past 6 months, were taking medications, were pregnant, lactating, or expecting to become pregnant were excluded from the study. Individuals who were unable to lie down and then get up from the floor without assistance were also excluded from the study. The study took place between months of June and September.

Assessments

The AG and CG were assessed at baseline and again after 6 weeks. On the day of assessments, participants were asked refrain from exercise, not to eat a heavy meal, and not to consume products with caffeine 3 hours before testing and to remain normally hydrated. Participants reported to the laboratory; turned in their food records; were asked to void and change into a hospital gown; and were then assessed for body composition, anthropometrics, and abdominal endurance.

Dietary Intake. Three-day food records were submitted at baseline and 6 weeks. Participants recorded time, place, and amount of food and beverage consumed for 2 weekdays and 1 weekend day on each record. Food labels were encouraged to be included and food records were analyzed using Food Processor software (ESHA, Salem, OR, USA). Three-day food records have been shown to give valid and reliable estimates of dietary intake (2,22).

Body Composition and Anthropometrics. Body mass was assessed using a Detecto physician balance scale with a height rod (Webb City, MO, USA). Body mass index (BMI) was calculated as weight (kg) divided by height (m^2). Dual-energy x-ray absorptiometry (DXA) (GE Lunar, Madison, WI, USA) was used to assess whole and regional percent body fat (%BF). Android fat was a measure of fat around the abdomen and trunk region. Before assessment, women presented a negative pregnancy test obtained from the University Health Service Center and participants removed all metal accessories (glasses, rings, etc). After the whole-body scan on the DXA, waist circumference was measured at the narrowest part of the waist below the ribs and above the iliac crest using a spring-loaded Gulick tape measure (Lafayette Instrument Company, Lafayette, IN, USA). A Lange skinfold caliper (Beta Technology, Santa Cruz, CA, USA) and vertical fold was used to assess subcutaneous fat at the site marked 2.54 cm to the right of the umbilicus (8).

Table 1. Baseline characteristics of participants.*

	Control ($n = 10$)	Exercise ($n = 14$)	t	p
Age (y)	22.49 ± 0.97	24.50 ± 4.97	−1.22	0.23
Height (cm)	169.75 ± 8.07	166.57 ± 7.70	−0.97	0.34
Weight (kg)	70.45 ± 9.88	68.79 ± 10.26	−0.39	0.69
Body mass index ($kg \cdot m^{-2}$)	24.47 ± 3.61	24.70 ± 3.14	−0.16	0.86
Body fat (%)	35.66 ± 9.33	35.98 ± 8.86	−0.08	0.93

*Values are given as mean ± *SD*.

Abdominal Endurance. Two strips of masking tape were horizontally placed 8.9 cm apart and parallel to each other on a mat. Lying supine, knees bent, feet flat on the mat, and arms extended with palms down so the fingers touched the top of the proximal strip of tape, each participant curled the trunk so that the fingers slid to the top of the distal strip of tape. If the fingers did not touch the tape or if the feet came off the floor, the repetition was not counted. The score was the total correct number of curl-ups performed in 1 minute.

Procedures

Abdominal Exercise Protocol. The CG did not engage in any form of abdominal exercise training and was asked to maintain their typical diet and ADL routine. There were no activity records kept during the study. The AG was not only asked to maintain their typical diet and ADL routine but also asked to perform 7 abdominal exercises, each with 2 sets of 10 repetitions, on 5 $d \cdot wk^{-1}$ for 6 weeks at the University Fitness Center.

As a warm-up, the AG participants first walked on a treadmill at speed of 1.1 $m \cdot s^{-1}$ for 5 minutes and then performed the prescribed exercise routine with 10–15 seconds of rest between each set. The total exercise session time, including warm-up, was approximately 15 minutes per session. The volume of this protocol was maintained for the duration of the study. Each repetition was performed in a slow and controlled manner to avoid injury and to reduce the effect of momentum when exercising.

During the first week, participants were monitored every session so that proper exercise form could be taught and supervised; thereafter, participants were supervised for 2 of the 5 sessions each week. All participants kept an exercise log of each non-supervised session completed. The log included the number of sets completed, and repetitions performed for each exercise and logs were turned in every 2 weeks to verify compliance to the study protocol. The exercises are described below in the order performed.

Bent-Knee Sit-Up. Lying supine with arms across the chest, knees bent, and feet flat on the floor, the shoulders were raised as far as possible to the knees and then back down to the starting position for 1 repetition.

Lateral Trunk Flexion. Standing with feet shoulder-width apart and a 2.27-kg dumbbell in the right hand, participants laterally flexed to the right as far as possible as the dumbbell slid down the lateral right thigh. This was counted as 1 repetition, and after 10 repetitions, the same was performed on the opposite side to count as 1 set. The weight was increased by 0.9 kg every alternate day until 6.36 kg was reached.

Leg Lifts. Sitting at the end of the bench, hands grasping the sides of the bench distally while the trunk was slightly inclined posteriorly with knees slightly bent and extended parallel to the floor, participants flexed the trunk and brought the knees to the chest and then back out for 1 repetition.

Oblique Crunch. Lying supine, left ankle resting on bent right knee with right foot flat on the floor and hands behind the neck, the right elbow was raised to the left knee and then returned to the floor. After 10 repetitions, the same was performed on the opposite side for 1 set.

Stability Ball Crunch. With the lower back on the ball, the trunk parallel to the floor and arms across the chest, the shoulders were raised until the trunk was at a 45° angle and then returned to the starting position for 1 repetition.

Stability Ball Twist. Lying supine, arms extended to the sides on the floor, legs bent at the knee with lower legs resting on the ball, participants slowly twisted at the waist to the right until the knees touched the floor and then returned to the starting position. After 10 repetitions, the same was performed on the opposite side for 1 set.

Abdominal Crunch. Lying supine, knees bent, feet flat on the floor and hands pointed to the knees, shoulders were raised until the fingers touched the kneecaps and then returned to the starting position for 1 repetition.

Statistical Analyses

Independent *t*-tests were used to assess differences in baseline characteristics between groups. A 2-way factorial analysis of variance (group × time) with repeated measures on the second factor was conducted to determine the effect of groups (control and experimental) and time (pretest and posttest) on the dependent variables (body mass, abdominal strength, body composition, waist circumference) using SPSS for Windows (version 15). In the case of a significant interaction of time × group, post hoc analysis (*t*-tests) was used to determine where differences occurred. If no interaction was evident, the main effect of each factor was explored. Where interactions are nonsignificant, only the main effects are reported. In the case of significance, partial eta squared was reported as the effect size (ES), with an ES of $\geq$0.8 considered large, 0.5 moderate, and $\leq$0.2 small. Statistical significance was set at $p \leq 0.05$ for all tests.

Results

No differences existed between the groups at baseline testing (Table 1). Participants were healthy, young, majority male (58%), and nonsmokers. Eighteen participants were Asian, 6 were Caucasian, and all female participants were premenopausal. In the exercise group, 3 participants completed at least 80% of the sessions and the remaining 11 participants completed 100% of sessions.

Dietary Intake. There was no group × time interaction for kilocalories for any macronutrient ($p > 0.05$). Macronutrient intake values for each group before and after treatment can be seen in Table 2. No significant main effect was evident between groups in total kcal, $F(1, 22) = 2.10$, $p = 0.65$; carbohydrates, $F(1, 22) = 1.70$, $p = 0.21$; fats, $F(1, 22) = 0.56$, $p = 0.46$; or proteins consumed, $F(1, 22) = 0.01$, $p = 0.96$.

Table 2. Daily kilocalories and macronutrient intake in control ($n = 10$) and exercise ($n = 14$) groups before and after 6 weeks.*†

	Pre		Post	
	Control	Exercise	Control	Exercise
EE (kcal)	1,747 ± 550	1,630 ± 636	1,752 ± 575	1,642 ± 575
Carbohydrate (g)	280 ± 72	235 ± 92	282 ± 73	236 ± 90
Fat (g)	42 ± 21	48 ± 25	41 ± 23	65 ± 22
Protein (g)	61 ± 23	63 ± 24	65 ± 22	62 ± 23

*Values are given as mean ± *SD*.
†No significant interactions were observed ($p > 0.05$). EE = energy expenditure.

Additionally, there was no significant main effect of time for total kcal, $F(1, 22) = 0.73$, $p = 0.40$; carbohydrates, $F(1, 22) = 0.17$, $p = 0.68$; fats, $F(1, 22) = 0.14$, $p = 0.70$; or proteins consumed, $F(1, 22) = 0.81$, $p = 0.38$.

Body Composition and Anthropometrics. There was no group × time interaction for any body composition or anthropometric outcome ($p > 0.05$). The main effect of group was not significant for body weight, $F(1, 22) = 0.12$, $p = 0.73$, and for BMI, $F(1, 22) = 0.03$, $p = 0.85$. The main effect of time was also not significant for body weight, $F(1, 22) = 0.71$, $p = 0.41$, and for BMI, $F(1, 22) = 0.43$, $p = 0.52$ (Table 3).

There was no significant main effect in total body fat percent between groups assessed by DXA, $F(1, 22) = 0.01$, $p = 0.992$ and in android fat percent between groups, $F(1, 22) = 0.01$, $p = 0.971$ (Table 3). The main effect of time when groups were combined in total body fat percent, however, was significant, $F(1, 22) = 5.28$, $p = 0.03$, ES = 0.21 with total body fat decreasing by 0.75% from pre to posttesting. This trend was also evident in android fat percent, $F(1, 22) = 4.39$, $p = 0.048$, ES = 0.18, with a decrease of 0.94% from pre to posttesting. Additionally, there was no main effect of group for waist circumference between CG (81.3 ± 2.5 cm) and AG (80.1 ± 2.2 cm) participants, $F(1, 22) = 0.13$, $p = 0.72$, nor was there a main effect of time from baseline testing (81.1 ± 1.7 cm) to posttesting (80.3 ± 1.7 cm), $F(1, 22) = 1.51$, $p = 0.232$.

Abdominal skinfolds increased significantly from baseline (27.6 ± 1.4 mm) to posttesting (29.1 ± 1.5 mm) when groups were combined, $F(1, 22) = 4.39$, $p = 0.048$, ES = 0.22. There were no significant differences, however, between the control (28.7 ± 2.2) and exercise group (28.1 ± 1.9) when time was combined, $F(1, 22) = 0.05$, $p = 0.82$.

Abdominal Endurance. The interaction between group and time was significant for the abdominal endurance test, $F(1,22) = 5.98$, $p = 0.02$, and post hoc analysis suggest a significant increase of 5.5 ± 7.3 curl-ups from pre to posttesting in CG, $t(9) = -2.38$, $p = 0.04$, ES = 0.38, and a significant increase of 14.6 ± 10.0 curl-ups from pre to posttesting in AG, $t(13) = -5.45$, $p = 0.001$, ES = 0.69. The AG performed 5.2 ± 3.4 more curl-ups at baseline testing compared to CG, but this was not significantly different,

Table 3. Body mass and composition before and after 6 weeks of abdominal exercise in control ($n = 10$) and exercise ($n = 14$) groups.*†‡§

	Pre		Post	
	Control	Exercise	Control	Exercise
Body weight (kg)	70.4 ± 9.8	68.9 ± 10.2	70.8 ± 10.1	69.4 ± 11.4
BMI ($kg \cdot m^{-2}$)	24.5 ± 3.6	24.7 ± 3.1	24.6 ± 3.5	24.8 ± 3.0
Total body fat (%)	35.6 ± 9.3	35.9 ± 8.8	35.3 ± 9.6	34.8 ± 8.3
Android fat (%)	43.1 ± 9.3	43.5 ± 9.1	46.8 ± 6.6	42.3 ± 9.1

*BMI = body mass index.
†Values are given as mean ± *SD*.
‡No significant interactions were observed ($p > 0.05$).
§No significant changes within group were observed.

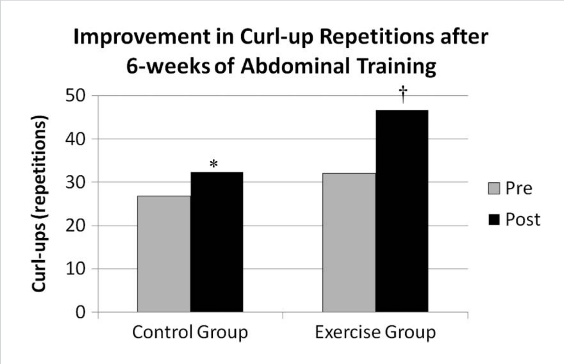

Figure 1. Improvement in curl-up repetitions after 6 weeks of abdominal training. *Significantly greater than control group pretest ($p = 0.041$). †Significantly greater than control group post test ($p = 0.008$) and exercise group pretest ($p = 0.001$).

$t(22) = -1.53$, $p = 0.139$. After 6 weeks of abdominal training however, AG performed significantly more repetitions (14.4 ± 4.9 curl-ups) than CG, $t(22) = -2.92$, $p = 0.008$, ES = 0.84 (Figure 1).

Discussion

The purpose of this study was to investigate the effect of 6 weeks of abdominal exercises on abdominal fat. Six weeks of abdominal exercises in the AG resulted in a greater abdominal endurance compared to the CG; however, abdominal exercise did not result in change in measures of abdominal fat (android fat measured by DXA, waist circumference, abdominal skinfold) compared to the CG.

In this study, both groups significantly improved on the curl-up test but the AG performed a significantly greater amount of repetitions per minute than the CG at the posttest. Specifically, each participant spent approximately 15 $\text{min}\cdot\text{d}^{-1}$ in abdominal exercises, and this was sufficient time to elicit significant improvements in abdominal muscle endurance. The greater increase in curl-ups per minute in the AG is not surprising and supports other investigations that strength increases with resistance training exercise (16). The improvement in the CG may be attributed to the fact that participants were familiar with the abdominal assessment protocol, wanted to perform better than the first test, or other testing effects (21). Participants in the AG likely performed better because of an increase in muscular endurance resulting from the exercise training and showed that the intervention was successful to improve abdominal muscular endurance.

In this study, there was no significant difference between the AG and CG for android fat as measured by DXA, waist circumference, or abdominal skinfold measurements. Few studies are available examining the effects of abdominal exercise on measures of abdominal fat and report conflicting results. Results from this study were consistent with those of Katch et al. (10), where no change in girth at the waistline was found after a 27-day sit-up exercise program (10). Additionally, Schade et al. (19) found no significant difference in fat distribution between generalized exercise and spot exercise group after 6 weeks of training (19). On the contrary, Mohr (14) found significant reductions in girth at the waist and umbilicus after 4 weeks of training without appreciable loss in weight (14). Work from Noland and Kearney (15) supported the results of Mohr (14) that localized exercise might be effective in reducing girth at that site (14,15). Recently Kostek et al. (12) showed a significant reduction in the subcutaneous fat in a trained arm compared to an untrained arm only in men ($p < 0.05$) after 12 weeks of supervised resistance training when measured by the skinfold technique but not by MRI (12). Kostek et al. found that the subcutaneous fat changes from resistance training varied by gender and assessment technique (12). In this study, there was no significant difference in abdominal skinfold measurement in AG and CG.

From an energy balance perspective, it does not appear likely that a 15-$\text{min}\cdot\text{d}^{-1}$ exercise regimen (5-minute warm-up and 10-minute abdominal exercise protocol) for the abdominal muscles would create a sufficient energy deficit to change body fat percentage and abdominal fat percentage. This is particularly true in light of recent physical activity guidelines from the American College of Sports Medicine for weight loss and prevention of weight gain that suggest 150–250 $\text{min}\cdot\text{wk}^{-1}$ is necessary to manage body weight (3). This study averaged only 75 minutes of abdominal exercise per week (15 minutes and 5 $\text{d}\cdot\text{wk}^{-1}$). Unfortunately, there were no activity records kept by either AG or CG during the experiment. However, there was no significant change in dietary intake in both groups on posttest from pretest. Additionally, there was no significant change in body weight in both groups, which suggests that the participants likely maintained their total activity in addition to their diet.

There were limitations in this study. First, the sample size was small. Thus, this study may be more appropriate as a pilot. Second, there was no diet control, and participants were asked to record food records for 3 days at the beginning and at the end of the study. It was assumed that participants recorded all food items in correct amount that was consumed. Third, intensity and duration remained constant and increasing either might have produced different results.

Practical Applications

In conclusion, abdominal exercise training was effective to increase abdominal strength but was not effective to decrease various measures of abdominal fat. Some individuals attempt to reduce their waistline by solely performing abdominal exercises possibly because of claims made by various abdominal equipment advertisements. The information obtained from this study can help people to understand that abdominal exercise alone is not sufficient to reduce waistline or subcutaneous abdominal fat. It is likely necessary to include aerobic exercise along with reducing energy intake to have more favorable changes in body fat percentage.

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