Liposuction Induces a Compensatory Increase of Visceral Fat Which Is Effectively Counteracted by Physical Activity: A Randomized Trial

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Context: Liposuction is suggested to result in long-term body fat regain that could lead to increased cardiometabolic risk. We hypothesized that physical activity could prevent this effect.

Objective: Our objective was to investigate the effects of liposuction on body fat distribution and cardiometabolic risk factors in women who were either exercise trained or not after surgery.

Design, Setting, and Participants: Thirty-six healthy normal-weight women participated in this 6-month randomized controlled trial at the University of Sao Paulo, Sao Paulo, Brazil.

Interventions: Patients underwent a small-volume abdominal liposuction. Two months after surgery, the subjects were randomly allocated into two groups: trained (TR, $n = 18$, 4-month exercise program) and nontrained (NT, $n = 18$).

Main Outcome Measures: Body fat distribution (assessed by computed tomography) was assessed before the intervention (PRE) and 2 months (POST2), and 6 months (POST6) after surgery. Secondary outcome measures included body composition, metabolic parameters and dietary intake, assessed at PRE, POST2, and POST6, and total energy expenditure, physical capacity, and sc adipocyte size and lipid metabolism-related gene expression, assessed at PRE and POST6.

Results: Liposuction was effective in reducing sc abdominal fat (PRE *vs.* POST2, $P = 0.0001$). Despite the sustained sc abdominal fat decrement at POST6 ($P = 0.0001$), the NT group showed a significant 10% increase in visceral fat from PRE to POST6 ($P = 0.04$; effect size $= -0.72$) and decreased energy expenditure ($P = 0.01$; effect size $= 0.95$) when compared with TR. Dietary intake, adipocyte size, and gene expression were unchanged over time.

Conclusion: Abdominal liposuction does not induce regrowth of fat, but it does trigger a compensatory increase of visceral fat, which is effectively counteracted by physical activity. (***J Clin Endocrinol Metab* 97: 2388–2395, 2012)**

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Abbreviations: Apo, Apolipoprotein; BMI, body mass index; ES, effect size; HDL, high-density lipoprotein; LDL, low-density lipoprotein; NT, nontrained; POST2, 2 months after surgery; PRE, before the intervention; RM, repetitions maximum; TR, trained; VO_{2max}, maximal oxygen uptake.

Liposuction is one of the most popular esthetic surgeries performed worldwide (1), but its long-term impact on health remains unclear. It has been speculated that the immediate decrease in body fat may affect body composition and metabolic profile by triggering feedback mechanisms of body fat regain (2). In several species, surgical fat removal is accompanied by fat regain within a few weeks, mostly due to compensatory fat growth in the intact depots (3, 4). A recent trial (5) confirmed that women undergoing liposuction gain upper-body fat within 6 months, which may be associated with increased cardiovascular risk (6).

Studies of the long-term effects of liposuction present some limitations. First, although the American Academy of Cosmetic Surgery (7) has recommended liposuction as a cosmetic procedure for normal to overweight women, most available studies have evaluated obese individuals (8–16). Second, to the best of our knowledge, only one study has assessed the regrowth or the compensatory growth of fat (5). Finally, and most importantly, no control for the subjects' physical activity levels has been provided (5, 8–18). The latter drawback may be considered an important confounder because exercise *per se* is believed to improve body composition (19) and cardiometabolic risk factors (20, 21). In this context, it is plausible that the effects of liposuction may be highly impacted by physical activity levels after the surgical procedure.

Thus, the purpose of this study was to investigate the effects of small-volume (removal of <4 liters of fat aspirate) abdominal liposuction on body fat distribution and cardiometabolic risk factors in normal-weight women who were either exercise trained or not after surgery. We hypothesized that liposuction surgery would cause body fat regain and redistribution in physically inactive subjects, whereas a supervised exercise training program would counteract such a detrimental outcome.

Subjects and Methods

Subjects

Thirty-six physically inactive (*i.e.* not engaged in any form of regular physical activity program for at least 6 months) women (20–35 yr old) were eligible to participate in the study. The exclusion criteria included body mass index (BMI) 30 kg/m^2 or higher, smoking, cardiovascular diseases and/or musculoskeletal disturbances that precluded exercise participation, metabolic disorders (*e.g.* hypertension, diabetes, glucose intolerance, thyroid dysfunction, and dyslipidemia), unstable weight (*i.e.* fluctuations over 5% body weight within the last 6 months), previous liposuction surgery, and current use of medications including antidepressants, appetite suppressants, thyroid hormone medication, orlistat, topiramate, diuretics, antiinflammatories or antibiotics. All patients used oral contraceptives. The study was approved by the local ethics committee, and all subjects provided written informed consent before entering the study.

Study design

Experimental protocol

A 6-month randomized controlled trial was conducted between May 2010 and April 2011 in Sao Paulo, Brazil (registered at clinicaltrial.gov as NCT01174485) according to the CONSORT guidelines. All subjects underwent a small-volume liposuction surgery. Two months after surgery, the subjects were randomly allocated into one of the two groups [trained (TR) or nontrained (NT)] using a computer-generated randomization code. TR subjects undertook a 4-month exercise program. NT subjects remained physically inactive throughout the study. Before the intervention (PRE), 2 months after surgery (POST2), and 6 months after surgery (POST6), food intake, body composition, oral glucose tolerance test, and blood analysis were assessed. Energy expenditure, adipocyte size, gene expression, and physical capacity were assessed at PRE and POST6 (60–72 h after the last training session in the TR group). Subjects were instructed to maintain their food intake pattern throughout the study.

Liposuction surgery

After a medical evaluation, subjects underwent a small-volume tumescent abdominal liposuction. A mean of 1240.3 ± 363.6 ml of fat aspirate supernatant was harvested.

Exercise training

Two months after surgery, subjects in the TR group began a 4-month (three times per week) exercise program. Each session consisted of a 5-min warm-up followed by strength exercises [eight exercises for the major muscle groups; one (during the first week as an adaptation training period) to three sets of eight to 12 repetitions maximum (RM) per exercise; 30 min/session] and by aerobic exercise on a treadmill (30–40 min/session) at an intensity corresponding to the respiratory compensation threshold [approximately 75% of the maximal oxygen uptake (VO_{2max})] monitored using a heart rate monitor.

The aerobic fitness was assessed by an incremental VO_{2max} test, whereas muscle strength assessment consisted of a one-RM protocol to determine both the upper-body (bench press) and lower-body (knee extension) muscular strength after a familiarization period.

Body composition assessment

The total fat mass and fat-free mass were assessed using hydrostatic weighing (22).

The sc fat of the pelvis, thigh, and abdomen as well as the visceral fat was assessed with computed tomography using a Siemens SOMATON Plus 4 scanner (Siemens Medical Systems, Iselin, NJ) (one 10-mm-thick slice for each site, 0.75 rotations/sec, 120 kV, 68 mA). The pelvic slice was obtained at the major trochanter, the thigh slice was obtained at the upper third of the thigh, and the abdominal slice was obtained at the umbilical scar, which allowed the delineation of total and visceral fat areas (23). The visceral abdominal fat area was defined by drawing a line within the muscle wall surrounding the abdominal cavity. Abdominal sc fat area was determined by the difference between total abdominal fat and visceral abdominal fat. Density values for area quantification were

−30 to −190 Hounsfield units for adipose tissue and 30–100 Hounsfield units for muscle tissue (24).

Total energy expenditure assessment

To determine the total energy expenditure over an 8-d free-living period, a two-point doubly labeled water method was used in a subsample of patients (n = 12 per group), as described elsewhere (25).

Adipose tissue biopsy

Subcutaneous adipose tissue biopsies (approximately 300 mg) were obtained from the abdominal and thigh sites under local anesthesia after a 10-h overnight fast (subsample of patients; n = 6 per group). An aliquot of the removed tissue was immediately placed in 4% paraldehyde and transferred to 70% alcohol 24 h later for adipocyte size analysis. Another aliquot of the removed tissue was flash frozen in liquid nitrogen and stored at −80 C for gene expression analysis.

Adipocyte size

The adipose tissue for histological analysis was embedded in paraffin and sectioned into 5-μm cross-sections. Sections were then stained with hematoxylin and eosin. Slides were examined under an optical microscope (KS-300; Carl Zeiss, Oberkochen, Germany). Sixty adipocytes were analyzed for each sample. The adipocyte diameter was measured using an image analysis computer program (UTHSCSA Image Tool).

Gene expression analysis

The expression of adipogenic and lipid metabolism-related genes was assessed using real-time PCR. RNA was purified from the adipose tissue using a commercially available kit (RNeasy Lipid Tissue Mini Kit; QIAGEN, Hilden, Germany) according to the manufacturer's protocol. cDNA was then synthesized after a standard RT-PCR protocol. Quantitative PCR was performed as previously described (26) (primer sets are described in Supplemental Table 1, published on The Endocrine Society's Journals Online web site at http://jcem.endojournals.org).

Blood analysis

Blood samples were collected after a 10-h overnight fast. Serum leptin levels were assessed using an ELISA kit (Linco Research, St. Charles, MO). Serum levels of blood cholesterol, high-density lipoprotein (HDL) cholesterol, and triglycerides were assessed via colorimetric enzymatic methods (CELM, Sao Paulo, Brazil). Very-low-density lipoprotein and low-density lipoprotein (LDL) cholesterol levels were calculated (27). Serum apolipoprotein (Apo)A1 and ApoB levels were determined via immunoturbidimetric assays (Roche Diagnostics, Mannheim, Germany).

Oral glucose tolerance test

After a 10-h overnight fast, the patients were given a glucose challenge (75 g glucose). Blood samples were collected before and at 30, 60, 90, and 120 min after glucose administration. Plasma glucose levels were assessed by a colorimetric enzymatic assay (Bioclin, Belo Horizonte, Brazil) whereas insulin levels were assessed using human-specific RIA techniques (Diagnostic Products Corp., Los Angeles, CA).

Food intake assessment

Food intake was assessed by a 7-d food record, according to a validated protocol (28). Energy, macronutrients, cholesterol, fiber, and fatty acid intake were analyzed by the Brazilian software Dietpro (version 5i, 2008–2009; Federal University of Viçosa, Minas Gerais, Brazil).

Statistical analysis

To our knowledge, no studies have reported the associated effects of liposuction and exercise on body composition in humans. Therefore, we based our sample-size calculation on the effects of exercise training without dietary restriction on body composition. We estimated that with nine participants in each group, the study would have more than 80% power at an α-level of 5% to detect a significant difference between groups in total body fat, assuming an effect size (ES) of 0.6, with a pooled SD of 6.0 (6).

Intention-to-treat analysis was used for each comparison, irrespective of the compliance with exercise training. After the normality and homogeneity of the variance were confirmed, the dependent variables were compared using a mixed model (SAS version 8.2; SAS Institute Inc., Cary, NC). Single-degree-of-freedom contrasts were used to determine whether the means significantly differed between groups. Finally, ES were estimated for the POST6 assessments using the pooled SD of the two independent samples at POST6 (29). The significance level was previously set at $P < 0.05$.

Results

Patients

One hundred fifty-six subjects responded to the invitation to participate in this study. Thirty-nine subjects met the inclusion criteria and were randomly assigned to the experimental groups. Two subjects withdrew from the study for personal reasons (NT group), and one did not complete all of the final exams (TR group). Thus, 36 patients were analyzed (TR = 18; NT = 18) (Supplemental Fig. 1). No between-group differences were observed at baseline for any of the parameters analyzed (Table 1).

Food intake and adherence to the exercise program

The adherence to the exercise program was 74.0 ± 13.2%. Food intake did not significantly differ within or between groups (Supplemental Table 2).

Body composition

Body weight, fat mass, and sc fat mass similarly decreased in both groups from PRE to POST2 ($P < 0.0001$), consistent with the amount of fat aspirated during liposuction (approximately 1 kg). Thigh, pelvic, and visceral fat areas and fat-free mass remained unchanged 2 months after surgery (Table 2).

TABLE 1. Subjects' baseline characteristics

Variable	TR (n = 18)	NT (n = 18)	Difference (95% CI)	*P* (TR *vs.* NT)
Body weight (kg)	61.7 (5.4)	59.7 (5.8)	1.9 (−3.8–7.7)	0.9
BMI (kg/m^2)	23.2 (1.3)	23.0 (1.8)	0.2 (−1.4–1.9)	1.0
% body fat	28.7 (3.4)	29.3 (3.6)	−0.6 (−3.9–2.8)	1.0
VO_{2max} (ml/kg · min)	31.1 (3.1)	30.5 (4.6)	0.6 (−2.7–3.8)	0.9
Total cholesterol (mg/dl)	180.5 (30.8)	177.0 (22.9)	3.2 (−22.9–29.3)	0.99
LDL cholesterol (mg/dl)	94.6 (22.3)	95.0 (24.0)	−1.2 (−25.4–23.0)	1.0
HDL cholesterol (mg/dl)	66.3 (13.3)	61.3 (16.6)	5.0 (−9.1–19.1)	0.90
TG (mg/dl)	98.2 (38.6)	104.8 (43.9)	−6.7 (−48.5–35.2)	0.99
Plasma glucose (mg/dl)	88.4 (8.8)	86.7 (8.9)	1.7 (−5.2–8.6)	0.97
Plasma insulin (mg/dl)	7.7 (3.7)	8.7 (3.8)	−0.9 (−4.8–2.8)	0.97

CI, Confidence interval; TG, triglycerides.

Despite a regain in body weight (PRE *vs.* POST6: TR, $P = 0.98$; NT, $P = 0.32$; within-group comparison), abdominal sc fat remained decreased in both groups (PRE *vs.* POST6: TR, $P = 0.0001$; NT, $P = 0.0001$; within-group comparison) 6 months after surgery. Additionally, the NT group showed a similar total fat mass at POST6 when compared with PRE ($P = 0.13$, within-group comparison). In contrast, the TR group showed a sustained de-

TABLE 2. Effects of liposuction combined with exercise training on body composition and energy expenditure in adult women

Variable	TR (n = 18)	NT (n = 18)	Difference (95% CI)	*P* (TR *vs.* NT)
Body weight (kg)				
PRE	61.7 (5.4)	59.7 (5.8)	1.9 (−3.8–7.7)	0.92
POST2[a]	60.8 (5.2)	58.5 (6.1)	2.3 (−3.4–8.1)	0.84
POST6	61.4 (5.7)	58.9 (6.4)	2.5 (−3.2–8.3)	0.79
Fat mass (kg)				
PRE	17.9 (3.0)	17.6 (3.2)	0.3 (−2.8–3.4)	0.99
POST2[a]	16.7 (2.7)	16.1 (3.1)	0.6 (−2.5–3.7)	0.99
POST6	16.3 (2.8)[b]	16.6 (3.5)	−0.4 (−3.5–2.7)	0.99
Lean mass (kg)				
PRE	43.9 (3.7)	42.3 (3.9)	1.7 (−2.1–5.4)	0.79
POST2	44.2 (3.7)	42.4 (4.1)	1.8 (−1.9–5.6)	0.73
POST6	45.1 (3.8)[b,c]	42.2 (4.1)	2.9 (0.2–5.5)	0.03[d]
Abdominal sc fat area (cm^2)				
PRE	246 (42)	244 (52)	2.5 (−45.5–50.6)	1.0
POST2[a]	166 (36)	170 (42)	−3.5 (−42.6–35.6)	0.99
POST6[a]	159 (30)	170 (49)	−11.4 (−51.8–29.0)	0.96
Abdominal visceral fat area (cm^2)				
PRE	42.9 (10.2)	43.1 (14.9)	−0.14 (−13.1–12.8)	1.0
POST2	41.2 (11.0)	42.5 (14.7)	−1.35 (−14.3–11.6)	0.99
POST6	38.1 (9.1)	47.2 (14.2)[b,c]	−9.15 (−18.1 to −0.2)	0.04[d]
Thigh sc fat area (cm^2)				
PRE	173 (26)	164 (32)	8.5 (−22.1–39.2)	0.96
POST2	174 (32)	168 (34)	4.9 (−26.4–36.2)	0.99
POST6	162 (28)[b]	164 (37)	−1.6 (−32.3–29.0)	1.0
Pelvic sc fat area (cm^2)				
PRE	308 (48)	291 (51)	17.0 (−34.1–68.2)	0.90
POST2	310 (61)	293 (52)	19.4 (−30.6–69.6)	0.83
POST6	292 (50)[b]	292 (61)	0.5 (−56.7–57.8)	1.0
Energy expenditure (kcal)				
PRE	2271 (195)	2184 (262)	87.6 (−196.7–372.0)	0.82
POST2				
POST6	2336 (214)	2063 (292)[b]	273.7 (63.9–483.5)	0.01[d]

Data are expressed as mean (SD), estimated mean of differences [95% confidence interval (CI)] and level of significance (*P*) between TR *vs.* NT (mixed model for repeated measures). No significant differences were found between groups at baseline.

[a] Main time effect: different from PRE, $P < 0.05$.

[b] Within-group differences: different from PRE, $P < 0.05$.

[c] Within-group differences: different from POST2, $P < 0.05$.

[d] Between-group differences.

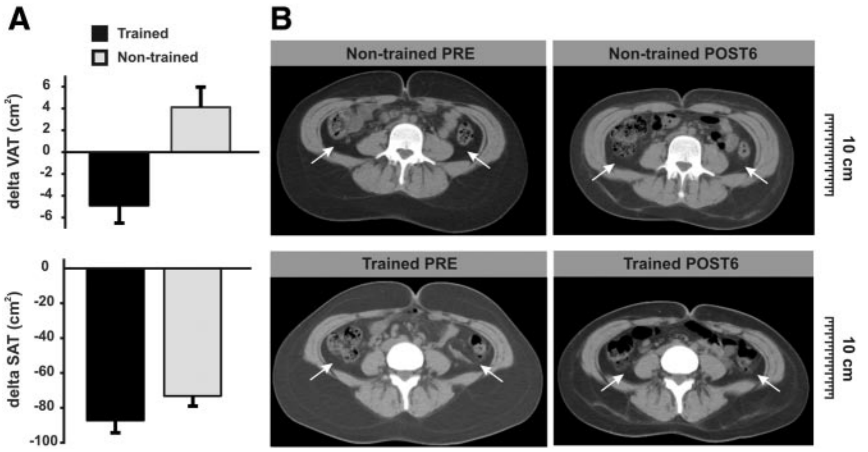

FIG. 1. A, Absolute change in abdominal sc adipose tissue (SAT) and visceral adipose tissue (VAT) area from PRE to POST6 (for the sake of clarity, we depicted SE *bars*). Absolute values are in Table 2. B, Illustrated computed tomography images of the abdomen. The *white arrows* indicate visceral fat.

creased fat mass (PRE *vs.* POST6, $P = 0.001$, within-group comparison) and increased fat-free mass at POST6 when compared with the NT group ($P = 0.03$; between-group effect; ES = 0.70). The TR group also presented decreased thigh and pelvic fat masses at POST6 (PRE *vs.* POST6, $P = 0.02$, within-group comparison) (Table 2).

Importantly, the NT group had a significantly increased visceral fat mass ($P = 0.05$, within-group comparison), whereas the TR group values remained unchanged ($P = 0.09$, within-group comparison). As a result, a significant difference in visceral fat mass was observed between the NT and TR groups ($P = 0.04$; ES = −0.72) (Table 2 and Fig. 1).

Adipocyte size

There were no significant within- or between-group changes for abdominal and thigh sc adipocyte size ($P = 1.0$; ES = 0.005 and $P = -0.96$; ES = 0.29, respectively; between-group comparisons at POST6) (Supplemental Fig. 2).

Subcutaneous adipose tissue gene expression analysis

Abdominal and thigh gene expression of leptin, *HSL*, *C/EBP-α*, and *SREBP-c* were unchanged across time in both groups. Similarly, no changes were observed in *LPL* and *PPARγ* abdominal gene expression within or between groups at any time. Conversely, thigh gene expression of *LPL* and *PPARγ* were decreased by approximately 50% in the TR group from PRE to POST6 ($P = 0.03$ and $P = 0.002$, respectively, within-group comparisons) (Supplemental Fig. 3).

Total energy expenditure

The NT group showed decreased total energy expenditure from PRE to POST6 compared with the TR group ($P = 0.04$; ES = 0.95) (Table 2).

Cardiometabolic risk factors

The glycemic area under the curve was unchanged throughout the study in both groups. However, the TR group showed a significant decrease in the insulinemic area under the curve at POST6 when compared with the NT group ($P = 0.01$; ES = −0.89).

HDL cholesterol, very-low-density lipoprotein cholesterol, and triglyceride levels were unchanged over time. However, main effects for time for increased LDL and total cholesterol were observed at POST2 ($P = 0.003$ and 0.001, respectively) and POST6 ($P = 0.002$ and $P = 0.03$, respectively). ApoAI and ApoB levels were also unchanged over time; hence, the LDL/ApoB ratio tended to increase at POST2 ($P = 0.06$) and significantly increased at POST6 in both groups ($P = 0.05$, main effect for time).

The TR group showed decreased leptin levels at POST6 as compared with the NT group ($P = 0.03$; ES = −0.61) (Supplemental Table 3).

Aerobic conditioning and muscle strength

The TR group had higher VO_{2max} ($P = 0.001$; ES = 1.21), one-RM bench press ($P = 0.0003$; ES = 1.27), and one-RM leg press ($P = 0.0001$; ES = 1.29) as well as lower resting heart rate ($P = 0.03$; ES = −0.86) values at POST6 than the NT group (Supplemental Table 4).

Discussion

The novel finding of this study was that exercise training is capable of counteracting the liposuction-induced compensatory growth of visceral fat in normal-weight women. According to the lipostatic theory proposed by Kennedy (30), a long-term energy balance is achieved through the feedback systems that constantly regulate adipose tissue depots. Thus, an abrupt liposuction-induced decrease in body fat may trigger compensatory mechanisms that would ultimately lead to body fat regain. In this study, computerized tomography did not reveal any evidence of fat regrowth at the aspirated depot (*i.e.* abdominal sc), which confirms previous experimental study findings (5). This observation was confirmed by the histological and the molecular data, which showed no changes in sc abdominal adipocyte size and expression of lipid metabolism genes. Altogether, these findings suggest that small-volume liposuction may be cosmetically efficient over a 6-month period after surgery.

Nonetheless, the significant regain of total fat mass in the NT subjects suggests a compensatory fat growth. Interestingly, there was no evidence of compensatory growth of fat in the pelvis and thigh depots. Instead, the visceral fat area was significantly increased in the NT subjects 6 months after surgery. This result is of great relevance because visceral fat is strongly associated with cardiometabolic risk being a strong predictor of morbidity and mortality independent of BMI (6). To our knowledge, this is the first study to demonstrate compelling evidence that liposuction induces compensatory fat growth in the visceral cavity as early as 6 months after surgery in physically inactive women. Importantly, the absence of upper-body fat evaluation constitutes a limitation in the present study because it is conceivable that body fat compensatory growth may have occurred in the upper body (*i.e.* breasts, back, and arms) as previously demonstrated (5, 31).

The mechanisms by which liposuction may cause compensatory fat growth remain elusive. Data from experimental studies have suggested that decreased energy expenditure rather than increased energy intake may account for the body fat restoration observed in lipectomized animals (32). Our data revealed the same pattern in humans, providing evidence of a liposuction-induced decrease in energy expenditure as an adaptive mechanism that leads to compensatory fat mass growth in humans. Furthermore, our data suggest that the fat loss *per se* plays a role in decreased energy expenditure because no changes in food intake, lean mass, or leptin levels were observed. Additional studies should comprehensively explore the underlying mechanisms of the liposuction-induced decrease in energy expenditure.

Despite the increase in visceral fat, classic cardiometabolic risk factors (*e.g.* insulin sensitivity and lipid profile) were not impaired by liposuction. Although the increase in total and LDL cholesterol levels might suggest otherwise, ApoB levels (which are related to small and dense LDL particles) (33) remained unchanged. This suggests that the increase in LDL cholesterol may not be derived from an increase in small, dense, atherogenic LDL particles (34) but instead to an increase in large, buoyant LDL particles.

The most striking finding of this study was the protective effect of exercise training in preventing the visceral fat compensatory growth in response to liposuction. Exercise is particularly effective in inducing lipolysis in visceral fat because this specific fat depot is more responsive to catecholamine-induced lipolysis (35). In fact, several studies have consistently shown that exercise training promotes significant reductions in visceral fat even without weight loss (21, 36). It is likely that the preserved energy expenditure observed in the trained group may have accounted for this protective effect, allowing for the maintenance of the energy balance. The exercise-induced increase in energy expenditure may be a consequence of 1) an acute increase in energy expenditure during exercise or 2) a transient increase in the resting metabolic rate 24–48 h after exercise (37). Moreover, the increase in lean mass may have contributed to the maintenance of energy expenditure by slightly augmenting or preserving the resting metabolic rate (38). In addition to its beneficial effects in energy balance and body composition, exercise training may also improve other cardiovascular risk factors. In this study, exercise training improved insulin sensitivity as well as strength and aerobic conditioning (*i.e.* VO_{2max}), which are both strong predictors of all-cause mortality in several populations (39).

The American Academy of Cosmetic Surgery (7) recommends that liposuction surgery should be "a cosmetic procedure for the removal of localized depots of fat that do not respond to diet and exercise." However, this statement may be misleading in some aspects. First, it falsely suggests that certain fat depots may be unresponsive to exercise training. However, responsiveness to exercise occurs in a graded rather than a binary fashion (40). If a depot of fat does not respond to diet and exercise, prescribing more exercise can be a more reasonable strategy. Second, we showed that liposuction may not be free of potential adverse metabolic consequences, especially for those not engaged in supervised exercise training.

The current study presents some limitations. First, this was a relatively short-term study. Additional studies with a longer follow-up are needed to investigate the long-term protection of exercise and whether liposuction-induced compensatory fat growth in the visceral cavity may cause metabolic disorders. Second, the lack of nonliposuctioned groups precluded the evaluation of the effects of exercise training and liposuction alone. Finally, the present results cannot be extrapolated to obese subjects. However, we intentionally selected normal-weight individuals to increase the external validity of the study, considering the recommendations of the American Academy of Cosmetic Surgery (7).

In conclusion, the current results indicated that a small-volume abdominal liposuction did not induce the regrowth of the aspirated fat but instead triggered a compensatory increase of visceral fat 6 months after surgery. Importantly, a 4-month, supervised exercise program prevented this compensatory visceral fat increase, increased fat-free mass, and improved physical capacity and insulin sensitivity. Based upon the present results, patients must be informed of the possible compensatory visceral fat growth and the potential associated risks as a consequence of a liposuction procedure. Additionally, health professionals are encouraged to recommend exercise training as an intervention after liposuction surgery.

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