Aesth Plast Surg
https://doi.org/10.1007/s00266-024-04373-8

ORIGINAL ARTICLES BODY CONTOURING

Metabolic Effects of Liposuction on Glucose and Insulin Homeostasis with and Without Abdominal Fat Removal

Hüseyin Kandulu[1]

4

Received: 5 June 2024 / Accepted: 6 September 2024

Abstract

Background Liposuction is a common cosmetic procedure aimed at addressing localized fat deposits. While metabolic disruptions associated with adiposity are well documented, the specific impacts of liposuction on metabolic parameters remain unclear.

Materials and Methods Seventeen individuals underwent liposuction inclusive of the abdominal area, while eleven underwent liposuction excluding the abdomen. Metabolic parameters including glucose, insulin, HOMA-IR, HbA1c, and C-peptide levels were measured preoperatively and postoperatively at 1, 3, and 6 months.

Results Both groups exhibited significant postoperative reductions in glucose, insulin, HOMA-IR, HbA1c, and C-peptide levels. However, the abdominal liposuction group demonstrated more pronounced reductions of these variables.

Conclusion These findings suggest that addressing abdominal adiposity may provide greater metabolic benefits following liposuction. Further research is warranted to explore the long-term sustainability and clinical implications of these metabolic improvements with additional markers.

Level of Evidence IV This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266

Keywords Liposuction · Metabolic effects · Glucose homeostasis · Insulin resistance · Abdominal fat removal

✉ Hüseyin Kandulu
info@kandulu.com

[1] Plastic and Reconstructive Surgeon, Kandulu Clinic for Plastic and Reconstructive Surgery, Terrace Fulya Teşvikiye Mah. Hakkı Yeten Cad. No. 13 Center 1 Kat 11 D.59, Teşvikiye, Istanbul, Turkey

Introductıon

Liposuction, a frequently performed cosmetic procedure, has gained considerable attention in recent times due to its effectiveness in addressing undesired and unbalanced fat distribution in the body. Meanwhile, the metabolic disruptions caused by excess adipose tissue and weight are well documented, with evidence indicating associations between both subcutaneous and visceral adiposity and conditions such as atherosclerosis, multiple cardiovascular risk factors, and metabolic syndrome in the general population [1–3]. However, there is inconsistency in the data regarding the specific impacts of fat removal through liposuction. Previous studies conducted vary in terms of design, sample population, homogeneity, and the markers used to assess metabolic health [4–6].

According to 2022 data from the World Health Organization (WHO), approximately 2.5 billion adults worldwide were classified as overweight, representing 43% of the global adult population [7]. Research has demonstrated that the percentage of body fat correlates with insulin resistance, even among individuals with a normal body mass index (BMI) [8]. Now, adipose tissue is increasingly recognized not only as an energy reservoir but also as an active endocrine organ capable of secreting various metabolically active biomolecules, and this endocrine activity plays a crucial role in glucose and energy metabolism. Moreover, the interplay between these molecules and organs like the liver directly influences metabolic homeostasis and balance within the body [9, 10].

While the liposuction procedure is primarily aims at reducing localized fat deposits, emerging evidence suggests that it may also influence various metabolic parameters involved in glucose and insulin homeostasis [11, 12]. Understanding the metabolic implications of liposuction is crucial for both clinicians and researchers, as it may offer insights into novel therapeutic approaches for metabolic disorders such as insulin resistance and type 2 diabetes. Hence, the present study aims to investigate the impact of liposuction, with and without abdominal fat removal, on metabolic parameters in patients undergoing the procedure.

Materıals and Methods

Patient Group

The study was carried out in a single plastic surgery clinic by the same surgeon. This study was conducted in accordance with the Declaration of Helsinki, and written informed consent was obtained from all subjects.

The study included two groups: one undergoing liposuction that included the abdominal area (n=17) and another undergoing liposuction that excluded the abdominal area (n=11). The exclusion criteria were as follows: individuals with clinical obesity (BMI greater than 30 kg/m^2), postmenopausal females, those with a previous history of liposuction surgery, individuals with conditions such as bleeding disorders, regular use of blood-thinning medication, a history of cancer, and those already diagnosed with a metabolic disease.

All patients underwent ultrasound-assisted liposuction with tumescent solution under general anesthesia. Liposuction was performed in one or more anatomical sites including abdomen, hips, waist, and thighs. The volumes of fat aspirated and tumescent solution used were quantified and recorded. The study parameters were glucose, insulin, HOMA-IR, HbA1c, and C-peptide. The levels of these parameters were measured using standard spectrophotometric, chromometric and immunological assays before the surgery, the next day of the surgery, and on the postoperative months 1, 3, and 6. Peripheral blood samples were obtained for the analyses, and all parameters were analyzed on the same day of the sampling. Also, weight and BMI of the individuals were measured, calculated, and recorded prior to the surgery.

All patients underwent ultrasound-assisted liposuction with tumescent solution under general anesthesia. The liposuction targeted one or more anatomical sites, including the abdomen, flanks, hips, waist, and thighs. The abdominal liposuction was considered as the conventional liposuction procedure comprising the anterior abdomen and the flanks. The volumes of fat aspirated and tumescent solution used were quantified and recorded. The study parameters included glucose, insulin, homeostasis model assessment of insulin resistance (HOMA-IR), HbA1c, and C-peptide levels. These parameters were measured using standard spectrophotometric, chromometric, and immunological assays before surgery, the day after surgery, and at 1, 3, and 6 months postoperatively. Peripheral blood samples were collected for the analyses, and all parameters were analyzed on the same day as sampling. The HOMA-IR was calculated by the formula as follows: Fasting Insulin(μU/mL)×Fasting Glucose(mg/dL)/405.

Additionally, the weight and BMI of the individuals were measured, calculated, and recorded prior to surgery.

Statistical Analysis

Statistical analysis was performed using SPSS v.17 (IBM Corp, Armonk, NY). Kolmogorov–Smirnov test was used to evaluate the normality of the study data. The data were presented as mean and standard deviations. Paired and unpaired Student's t-test was used to compare the variables within and between the groups. ANCOVA test was used for the covariates which are significantly different between the groups for adjustment. A p-value of less than 0.05 was considered statistically significant.

Results

The average age was 36.42±5.14 years for the abdominal liposuction group and 37.14±4.243 years for the non-abdominal liposuction group, showing no significant difference ($p=0.313$). Gender distribution, aspirated fat volume, and tumescent solution volume ($p=0.0213$; $p<0.01$; $p<0.01$, respectively) were significantly different between the groups. The BMI of the abdominal liposuction group was significantly higher compared to the non-abdominal group ($p<0.05$) (Table 1).

Follow-up Comparisons of Metabolic Variables

The comparison of study variables between and within the groups is presented in Table 2.

Table 1 Demographic and intraoperative variables of the study group

Variables	Liposuction including abdominal area (n=17) Mean±SD	Liposuction without abdominal area (n=11) Mean±SD	p value
Age (years)	36.42±5.14	37.14±4.243	0.313
F/M	10/6	11/0	**0.0213**
Aspirated fat volume (mL)	3943±1524	2367±1290	**<0.01**
Tumescent solution volume (mL)	7358±2354	5150±1103	**<0.01**
BMI (kg/m2)	27.47±5.193	22.79±1.506	**<0.05**

Significant values are highlighted in bold text

Table 2 Comparison of adjusted study variables on the follow-up points

Liposuction including abdominal area (n=17)			Liposuction without abdominal area (n=11)			p value***	p value**
Variables	Mean ±SD	p value*	p value**	Mean ±SD	p value*		
Glucose (mg/dL)							
Preoperative	101.4±13.15			103.7±14.36			0.646
Postoperative	92.00±8.910	**0.0127**		101.4±12.34	0.616		**<0.05**
Postoperative 1st month	92.78±6.572	**0.0287**	0.4910	97.34±2.828	**<0.05**	0.147	**<0.05**
Postoperative 3rd month	91.14±5.815	**0.0108**	0.6109	92.02±1.031	**0.0114**	**<0.05**	0.482
Postoperative 6th month	90.0±7.100	**0.0086**	0.8637	92.46±1.240	**0.0182**	0.8921	0.274
Insulin(uU/mL)							
Preoperative	18.43±14.98			16.20±5.977			**<0.05**
Postoperative	14.71±8.755	**0.0161**		13.350±4.899	0.078		0.267
Postoperative 1st month	10.26±7.144	**<0.001**	**0.046**	11.067±4.535	**<0.01**	0.128	0.482
Postoperative 3rd month	10.61±5.367	**<0.001**	0.225	10.897±6.493	**<0.01**	0.657	0.783
Postoperative 6th month	10.61±5.367	**<0.001**	0.615	11.124±6.015	**<0.01**	0.614	0.541
HOMA-IR							
Preoperative	4.097±3.852	0.4775		4.430±2.064			0.286
Postoperative	3.843±2.700	**0.4775**		4.248±2.367	0.742		0.238
Postoperative 1st month	2.314±1.605	**0.0147**	**0.042**	2.230±0.7495	**<0.01**	**<0.01**	0.549
Postoperative 3rd month	2.423±1.211	**<0.01**	0.348	2.007±1.276	**<0.01**	0.348	0.261
Postoperative 6th month	2.406±1.316	**<0.01**	0.618	2.319±1.783	**<0.01**	0.362	0.517
HbA1c (%)							
Preoperative	5.059±0.4496			5.163±0.1662			0.616
Postoperative	5.063±0.2432	0.4362		4.943±0.2974	0.517		0.672
Postoperative 1st month	4.983±0.05508	0.1550	0.2666	4.570±0.0283	0.289	0.117	0.149
Postoperative 3rd month	4.685±0.7941	**0.0184**	**0.0421**	4.784±0.1209	0.387	0.238	0.245
Postoperative 6th month	4.738±0.1779	0.0534	0.7952	4.603±0.097	0.326	0.374	0.264
C-peptide (ng/mL)							
Preoperative	4.053±2.175			4.067±1.539			0.831
Postoperative	3.349±1.641	**0.0105**		3.861±2.085	0.106		0.349
Postoperative 1st month	2.281±1.107	**<0.001**	0.0088	1.950±0.8757	**<0.001**	**<0.001**	0.416
Postoperative 3rd month	2.283±0.9375	**<0.001**	0.1600	1.905±1.710	**<0.001**	0.762	0.377
Postoperative 6th month	2.273±1.045	**<0.001**	0.6272	1.982±1.094	**<0.001**	0.794	0.416

Significant values are highlighted in bold text

*Difference with pre-op; **Difference with previous measurement; *** Difference between the study groups

Glucose

Postoperative glucose levels significantly decreased in the abdominal liposuction group across all follow-up points, with notable reductions at the 1st, 3rd, and 6th months ($p<0.05$). In the non-abdominal group, significant reductions were observed at the 1st and 3rd months postoperatively ($p<0.05$). Mean glucose concentrations at the postoperative and postoperative 1st month follow-up were significantly different between the groups.

Insulin Levels

The preoperative insulin levels were higher in the abdominal liposuction, on group ($p<0.05$). In the abdominal liposuction group, preoperative insulin levels significantly decreased postoperatively at all follow-up points ($p<0.001$). The non-abdominal group had significant reductions observed postoperatively at the 1st, 3rd, and 6th months ($p<0.01$).

HOMA-IR

The HOMA-IR significantly decreased in the abdominal group postoperatively, with reductions at the 1st, 3rd, and 6th months ($p<0.01$). The non-abdominal group also showed significant decreases in HOMA-IR at the same follow-up points ($p<0.01$).

HbA1c

HbA1c levels in the abdominal liposuction group showed a significant reduction at the 3rd month ($p=0.0184$). The non-abdominal group HbA1c levels did not show significant changes during the follow-up.

C-Peptide

C-peptide levels showed significant reductions in both groups postoperatively. The abdominal liposuction group yielded significant decreases at all follow-up points ($p<0.001$). The non-abdominal group also showed significant reductions postoperatively ($p<0.001$).

Discussion

Despite the various outcomes of liposuction on metabolic profile in the literature, most studies agree that it improves at least one component involved in carbohydrate metabolism.

To the best of our knowledge, this is one of the limited number of studies specifically focused on the variations in metabolic parameters following either abdominal liposuction or other forms of liposuction procedures.

Our results indicate that both groups experienced significant postoperative improvements in metabolic parameters. However, the abdominal liposuction group demonstrated more pronounced reductions, particularly in insulin and glucose levels, HOMA-IR, and C-peptide levels, suggesting enhanced metabolic benefits from the inclusion of abdominal area.

A recent study by Cero´n-Solano has evaluated the effectiveness of combining liposuction and abdominoplasty on metabolic health in normoglycemic Hispanic women without obesity [13]. The first group underwent liposuction only, while the second group had combined liposuction and abdominoplasty. While the women in the liposuction group had similar HOMA-IR levels before and 60 days after surgery, the liposuction combined with abdominoplasty group showed significantly reduced HOMA-IR values 60 days after surgery compared to their preoperative levels. Furthermore, this decrease was positively correlated with preoperative HOMA-IR and negatively correlated with the age of the subjects. Although we did not employ abdominoplasty in our study group, the comparison between two groups yielded similar results with this study. However, the abdominal liposuction group provided better endocrine system outcomes in terms of insulin and C-peptide levels.

Another study on the effects of large-volume liposuction on fasting insulin levels in overweight and obese premenopausal women between the ages of 21 and 40 years assessed the impact of the procedure on fasting insulin levels three months postoperatively. They found that large-volume liposuction of 7.36 ± 1.84 liters significantly improved fasting insulin levels, suggesting it could be beneficial in reducing metabolic risks [14]. However, it should be noted that liposuction is not an alternative weight loss tool, and should not be employed for such purposes. The beneficial metabolic impacts of liposuction should only be assessed as secondary outcomes of a cosmetic operation.

Gibas-Dorna et al. aimed to examine the metabolic changes induced by liposuction, specifically focusing on the release of major adipokines and insulin sensitivity in 17 overweight male patients, including six with type 2 diabetes [12]. The comparison with the age-matched controls without a comorbidity revealed similar weight reduction and a decrease in BMI at 1 to 2 months post-surgery, which was maintained after 6 months, alongside an improved insulin sensitivity at 1 to 2 months post-surgery. Yet, they could not detect significant changes in adiponectine or soluble leptin receptor levels. However, the volume of total aspirate ranged from 2200 ml to 3520 ml in their study group, and all subjects were overweight, suggesting that a larger volume of fat removal or inclusion of individuals with a normal weight might provide different results in terms of adipokine levels.

A recent study by Santos et al. investigated the effects of abdominoplasty on glucose, insulin, and lipid metabolism in 35 patients [4]. The patients were divided into two groups: one consisting of individuals with significant weight loss prior to abdominoplasty and the other comprising individuals without a weight loss history who also underwent abdominoplasty. The results showed no statistically significant changes in the metabolic parameters three months after surgery. However, there were notable differences in LDL and non-HDL cholesterol levels between the groups, suggesting that patients with significant weight loss demonstrated better control of LDL and non-HDL cholesterol levels despite having a higher weight and body mass index.

Research into the molecular causes of metabolic imbalances in obesity, metabolic syndrome, and the presence of excess weight is still ongoing. The comprehension of adipose tissue biology has significantly advanced, revealing that adipocytes are much more complex than being storage units for fat. An experimental study by Kulaj et al. shows that adipocyte-derived extracellular vesicles (AdEVs) enhance insulin secretion in pancreatic β-cells, influenced by the metabolic state of the adipose tissue [9]. AdEVs from diet-induced obese mice carry a functional protein cargo that increases β-cell sensitivity to glucose more than same group of vesicles obtained from lean mice. This suggests that AdEVs from obese and insulin-resistant adipocytes can boost compensatory insulin secretion, a common occurrence in the early stages of type 2 diabetes. Also, larger fat depots under obesity conditions secrete more AdEVs.

Epidemiological and metabolic studies suggest different fat types and locations have distinct roles and risks for metabolic diseases. Excess accumulation of both visceral and subcutaneous adipose tissues contributes to abdominal obesity but differ in structure, activity, and significance. It suggests that in individuals with impaired fat cell development, a positive calorie balance may lead to subcutaneous adipocyte hypertrophy, negatively addressing the energy storage and function. This insufficient subcutaneous fat storage can then lead to the redistribution of fatty acids to visceral fat, liver, and muscle, thereby increasing metabolic risk [15, 16]. Additionally, visceral fat in obesity produces pro-inflammatory substances, while higher amounts of visceral fat are associated with increased systemic levels of inflammation markers [17].

In the present study, although no significant difference was observed in HOMA-IR between the two groups of patients, all participants had an average preoperative HOMA-IR exceeding 2.5, indicating insulin resistance and impaired beta cell function. However, all patients experienced positive outcomes from the liposuction procedure, regardless of whether abdominal fat removal was included. Our research uniquely highlights the enhanced metabolic benefits specific to abdominal liposuction, evidenced by more significant reductions in insulin and glucose levels, HOMA-IR, and C-peptide levels, compared to the existing literature. Our findings underscore the potential for targeted fat removal to yield superior metabolic outcomes, contributing valuable insights to the ongoing discourse on liposuction's role beyond cosmetic improvement. However, a broader understanding of adipose tissue's complex role in metabolic health would be possible with the inclusion of adipose tissue-specific molecules such as glucagon-like peptide-1 (GLP-1), ghrelin, and leptin which play role in adipocyte functions and insulin sensitivity.

The current study has several limitations. Firstly, the follow-up period was relatively short, and the sample size was limited. Additionally, the study groups differed in terms of gender distribution, aspirated fat volume, and baseline BMI values. We also did not use radiological imaging to assess the impact of subcutaneous fat removal on visceral fat distribution. However, to avoid potential bias due to variations in fat distribution among different racial and ethnic groups, we only included individuals from the same country. Despite these limitations, the findings of this study provide valuable insights into the metabolic effects of liposuction for plastic surgeons.

In conclusion, the study's findings highlight significant postoperative metabolic improvements in patients undergoing liposuction, particularly in those who had the abdominal area included in the procedure. Both groups showed notable reductions in glucose and insulin levels, HOMA-IR, and C-peptide levels, indicating enhanced insulin sensitivity and overall metabolic function. However, the group with abdominal liposuction exhibited slightly more substantial reductions across these parameters, suggesting that addressing abdominal adiposity may yield greater metabolic benefits. Further research with a larger sample size and longer follow-up is warranted to explore the confirmation of our findings, as well as the long-term sustainability and broader clinical implications of these improvements.

Funding: None

Declarations

Conflict of interest The authors declare that they have no conflicts of interest to disclose.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent Informed consent was obtained from all participants.

References

1. Cornier MA, Despres JP, Davis N et al (2011) Assessing adiposity: a scientific statement from the American Heart Association. Circulation 124:1996–2019
2. Bays HE, Gonzalez-Campoy JM, Bray GA et al (2008) Pathogenic potential of adiposetissue and metabolic consequences of adipocyte hypertrophy and increased visceraladiposity. Expert Rev Cardiovasc Ther 6:343–368
3. Fox CS, Massaro JM, Hoffmann U et al (2007) Abdominal visceral and subcutaneous adi-pose tissue compartments: association with metabolic risk factors in the Framing-ham Heart Study. Circulation 116:39–48
4. Santos LRA, da Costa PR, Maia TS, Junior AC, Resende V (2023) Prospective cohort of parameters of glycemic and lipid metabolism after abdominoplasty in normal weight and formerly obese patiens. JPRAS Open. 17(37):155–162. https://doi.org/10.1016/j.jpra.2023.07.005
5. Seretis K, Demiri E (2015) Metabolic effects of large-volume liposuction for obese healthy women: a meta-analysis of fasting insulin levels. Aesthet Plast Surg 39(2):278–279. https://doi.org/10.1007/s00266-015-0447-2
6. Benatti FB, Lira FS, Oyama LM, do Nascimento CM, Lancha AH Jr. Strategies for reducing body fat mass: effects of liposuction and exercise on cardiovascular risk factors and adiposity. Diabetes Metab Syndr Obes. 2011;4:141-54. https://doi.org/10.2147/DMSO.S12143.
7. World Health Organization (2021) Obesity and overweight. World Health Organization. Accessed June 1 2024, Available at https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
8. Davis S, Hocking S, Watt MJ, Gunton JE (2023) Metabolic effects of lipectomy and of adipose tissue transplantation. Obesity (Silver Spring) 31(1):7–19. https://doi.org/10.1002/oby.23601
9. Kulaj K, Harger A, Bauer M et al (2023) Adipocyte-derived extracellular vesicles increase insulin secretion through transport of insulinotropic protein cargo. Nat Commun 14(1):709. https://doi.org/10.1038/s41467-023-36148-1
10. Booth A, Magnuson A, Fouts J, Foster MT (2016) Adipose tissue: an endocrine organ playing a role in metabolic regulation. Horm Mol Biol Clin Investig. 26(1):25–42. https://doi.org/10.1515/hmbci-2015-0073
11. Badran S, Habib AM, Aljassem G et al (2023) Metabolic changes after surgical fat removal: A dose-response meta-analysis. J Plast Reconstr Aesthet Surg 76:238–250. https://doi.org/10.1016/j.bjps.2022.10.055
12. Gibas-Dorna M, Szulińska M, Turkowski P et al (2017) The effect of VASER abdominal liposuction on metabolic profile in overweight males. Am J Mens Health 11(2):284–293. https://doi.org/10.1177/1557988316674841
13. Cerón-Solano G, Pacheco-López R, Hernández-Ordoñez R et al (2024) The effect of liposuction versus liposuction with abdominoplasty on insulin resistance in normoglycemic non-obese Mexican females: A prospective cohort study. Cir Esp (Engl Ed). 102(4):194–201. https://doi.org/10.1016/j.cireng.2023.11.019
14. Habib H, Abd Alazeem S, Abd AN (2018) Fasting insulin level changes after large volume liposuction. The Egyptian Journal of Hospital Medicine 73(3):6243–6251. https://doi.org/10.21608/ejhm.2018.12951
15. Danforth E Jr (2000) Failure of adipocyte differentiation causes type II diabetes mellitus? Nat Genet 26(1):13. https://doi.org/10.1038/79111
16. Badran S, Doi SA, Hamdi M, et al. 2023 Metabolic aspects of surgical subcutaneous fat removal An umbrella review and implications for future research Biomol Biomed 23(2): 235-247
17. Ellulu MS, Patimah I, Khaza'ai H, Rahmat A, Abed Y (2017) Obesity and inflammation: the linking mechanism and the complications. Arch Med Sci 13(4):851–863. https://doi.org/10.5114/aoms.2016.58928