

# Effectiveness of Cryolipolysis in Body Contouring and Fat Reduction: A Systematic Review and Meta-analysis

Alaa Hakami<sup>1\*</sup>, Alya Hakami<sup>1</sup>, Rayan Alghamdi<sup>2</sup>, Haya Alzahrani<sup>3</sup>, Adham Alghamdi<sup>3</sup>, Abdullah Qureshey<sup>4</sup>, Yousef Almail<sup>5</sup>, Manar Alfaqiri<sup>6</sup>, Maha Alsofiani<sup>7</sup>, Lana Hariri<sup>8</sup>, Hajar Alrashed<sup>9</sup>, Shahad Aldumkh<sup>10</sup>

1. Department of Surgery, Jazan University Jazan, Saudi Arabia
2. Department of Surgery, Al-Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia
3. Department of Surgery, Al-Baha University, Saudi Arabia
4. Department of Surgery, University of Jeddah, Jeddah, Saudi Arabia
5. Department of Surgery, Royal College of Surgeons in Ireland, Dublin, Ireland
6. Department of Surgery, University of Tabuk, Tabuk, Saudi Arabia
7. Department of Surgery, Taif university, Taif, Saudi Arabia
8. Department of Surgery, King Abdulaziz University, Jeddah, Saudi Arabia
9. Department of Surgery, Princesses Nourah University, Riyadh, Saudi Arabia
10. Department of Surgery, King Saud University, Riyadh, Saudi Arabia

## \*Corresponding Author:

Alaa Hakami

Department of Surgery, Jazan University Jazan, Saudi Arabia

Email: [alaahakami@jazanu.edu.sa](mailto:alaahakami@jazanu.edu.sa)

Received: 7/18/2025

Accepted: 11/15/2025

## ABSTRACT

**Background:** Cryolipolysis has emerged as a promising, non-invasive body contouring technique that employs controlled cooling to selectively eliminate adipocytes without damaging surrounding skin or tissues. As global demand rises for non-surgical aesthetic treatments, cryolipolysis offers an appealing alternative to traditional liposuction for individuals seeking fat reduction with minimal recovery time and fewer complications.

**Methods:** Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a comprehensive search of PubMed, Scopus, and Web of Science was conducted up to November 2024. Studies included were randomized controlled trials and prospective cohort studies evaluating the outcomes of cryolipolysis on body contouring. Statistical analysis was performed using Review Manager 5.4 software, calculating mean differences (MD) and 95% confidence intervals (CI).

**Results:** The use of cryolipolysis was associated with decreased BMI showing MD= -1.71 (95%CI: -2.6, -0.82, P=0.0002). However, no significant difference was observed regarding weight with MD= -1.81 (95%CI: -3.93, 0.31, P=0.09). The use of cryolipolysis was also associated with decreased circumference of different body parts with MD= -3.45 (95%CI: -5.55, -1.34, P=0.001), and I<sup>2</sup>=92%, P<0.00001 and decreased fat thickness with MD= -3.56 (95%CI: -4.63, -2.48, P<0.00001), and I<sup>2</sup>=95%, P<0.00001.

**Conclusion:** Cryolipolysis is effective in reducing BMI, local circumference, and fat thickness, confirming its utility for non-invasive body contouring. However, it does not significantly affect overall weight. The benefits are more pronounced in short-term follow-up and vary by body region. Further long-term and comparative studies are recommended.

## KEYWORDS

Cryolipolysis; Body Contouring; Non-Invasive Fat Reduction; BMI; Circumference; Fat Thickness

## Please cite this paper as:

Hakami A, Hakami A, Alghamdi R, Alzahrani H, Alghamdi A, Qureshey A, Almail Y, Alfaqiri M, Alsofiani M, Hariri L, Alrashed H, Aldumkh S. Effectiveness of Cryolipolysis in Body Contouring and Fat Reduction: A Systematic Review and Meta-analysis. *World J Plast Surg.* 2025;14(2):16-26. doi: 10.61882/wjps.14.3.16

## INTRODUCTION

Localized adiposity refers to the abnormal accumulation of fat in typical anatomical regions, constituting a significant cosmetic concern<sup>1</sup>. Body contouring represents a significant medical aesthetic need globally. The pursuit of an ideal body form has spurred the swift development of novel, non-invasive, comfortable, and safe procedures that need minimal recovery time<sup>2,3</sup>. Despite the effectiveness of liposuction in fat reduction and body reshaping, there remains a persistent demand for non-surgical and non-invasive alternatives that may offer comparable efficacy. The majority of patients decline surgery and invasive interventions, opting instead for non-invasive therapies that progressively achieve fat reduction and enhance texture and body contouring<sup>3,4</sup>.

Multiple therapies, such as ultrasound, radiofrequency, and mesotherapy, have been formulated to induce adipocyte death<sup>5-7</sup>. Each method utilizes a distinct mechanism to induce apoptosis or necrosis in the targeted adipocytes. In recent years, a novel approach for the noninvasive treatment of localized adiposity by cold-induced panniculitis, known as cryolipolysis, has emerged. Cryolipolysis has evolved as a novel non-invasive body contouring technique that use controlled cooling to selectively eliminate adipocytes without harming the skin and other tissues<sup>5</sup>. The cooling applicator is utilized on the targeted region to dissipate heat at a specified rate ( $\text{mW}/\text{cm}^2$ ) until a designated temperature is attained (e.g.,  $-7$  to  $1$  °C) for a predetermined duration<sup>6</sup>. Following a solitary treatment, adipocyte apoptosis and an elevation in the collagen to adipose tissue ratio occur through lobular panniculitis and thickening of the interlobular fibrous septae over several months, leading to a decrease in the thickness of the subcutaneous fat layer<sup>7</sup>. A study involving animals showed a 30–50% decrease in the thickness of the subcutaneous fat layer without altering serum lipid levels<sup>8</sup>. Prior clinical investigations demonstrated the safety and efficacy of cryolipolysis for the removal of localized subcutaneous fat in the abdomen<sup>9</sup> and flanks<sup>10</sup>. The treatment obtained permission from the US Food and Drug Administration (FDA) for fat removal in the flanks, belly, and thighs in 2010, 2012, and 2014, respectively<sup>11</sup>.

The current systematic review and meta-analysis

aimed to investigate the efficacy of cryolipolysis in contouring of different body parts.

## METHODS

### Searching databases

In accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines<sup>12</sup>, we conducted a search of PubMed, Scopus, and Web of Science from inception until November 2024 for articles meeting our eligibility criteria for inclusion in the systematic review and meta-analysis examining the use of cryolipolysis in body contouring. The search technique employed the Medical Subject Headings (MeSH) terms of two main keywords: was: “Cryolipolysis” AND “Contouring”.

The systematic review was registered on prospero with registration ID: CRD42024507038.

### Screening

The resulting articles from the searching process were uploaded to Rayyan software<sup>13</sup>. After which, we conducted the process of title, and abstract screening followed by full-text screening. These processes were conducted by four authors who worked independently, and any disagreements were settled by consensus or referred to a senior author if persisted. We incorporated papers featuring patients who underwent cryolipolysis for contouring and compared the different outcomes with baseline measurements. We incorporated randomized controlled trials (RCTs) and observational prospective cohort studies. We excluded case reports, reviews, and studies investigating different contouring techniques.

### Data extraction

This procedure was executed by four authors individually utilizing a pre-prepared Microsoft Excel spreadsheet. Disagreements were settled by consensus, and if they continued, the senior author intervened to resolve them. We retrieved the baseline data from the included studies, encompassing design, sample size, follow-up age, anatomical regions, and gender of the individuals. Furthermore, the outcome data were gathered for

the meta-analysis, encompassing baseline and post-treatment values of weight, body mass index (BMI), circumferences of the abdomen, thighs, arms, or other body regions subjected to cryolipolysis, as well as fat thickness or skinfolds.

### Quality and risk of bias assessment

Two independent researchers conducted quality assessment and risk of bias assessment, and any disagreements were resolved by consensus or by the senior author. We used the Cochrane risk-of-bias tool (Rob-2)<sup>14</sup>, which consists of five domains each with a set of questions. The results are then combined through a diagram to determine one of three levels of bias: low risk, some concerns, or high risk. We evaluated the quality of the included non-randomized studies using methodological index for non-randomized studies (MINORS) tool. The items received a score of 0 if unreported, 1 if reported but inadequate, and 2 if reported and adequate. A score of 0-5 is deemed very low quality, 5-8 is classified as low quality, 8-11 is regarded as moderate quality, and a score beyond 11 is categorized as excellent quality<sup>15</sup>.

### Statistical analysis

All phases of statistical analysis were performed utilizing Review Manager version 5.4 software<sup>16</sup>. We utilized the mean difference (MD) to compare continuous variables. We employed the random effects model for heterogeneous outcomes and the fixed effects model for homogeneous outcomes, with a confidence interval (CI) of 95% and a *P*-value of 0.05. The heterogeneity was assessed using I<sup>2</sup> and a *P*-value of 0.05. Subgroup analysis was also performed to account for the present heterogeneity in some outcomes.

## RESULTS

### Screening

The search yielded 245 articles, including 131 duplicates. We performed title and abstract screening following the elimination of duplicates from the remaining 114 articles. Subsequently, full-text screening was performed on 16 papers, resulting in the inclusion of 10 studies in the systematic review and meta-analysis<sup>17-26</sup> (Figure 1).

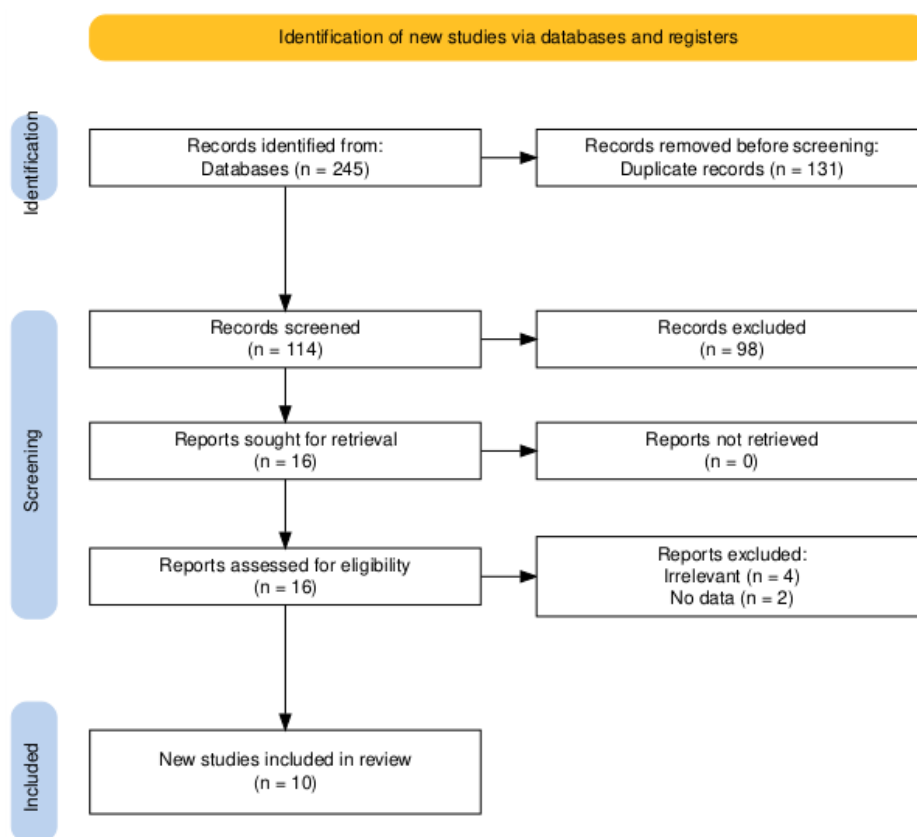


Figure 1: PRISMA flow diagram of searching and screening

### Baseline characteristics

We included 10 articles investigating the effects of cryolipolysis in the contouring of different body parts. Among the included studies, the design was prospective cohort in six of them, two RCTs, non-randomize clinical trial, and a prospective, multicenter, single arm clinical trial. The total sample size was 285 patients, with mean age ranging from 14 to 51.6 years old, and the majority of them were females. Most of the studies were conducted on the abdomen, while other studies included other body parts such as saddlebags, flanks, arms, and inner thighs. The follow-up period ranged from 2 to 6 months (Table 1).

### Quality and risk of bias assessment

According to MINORS, two studies were of moderate quality, and six were of excellent quality.

(Table 2) According to Rob-2, the two RCTs were deemed to have low risk of bias (Figure 2).

### Statistical analysis

The use of cryolipolysis was associated with decreased BMI showing MD= -1.71 (95%CI: -2.6, -0.82,  $P=0.0002$ ), and  $I^2=81%$ ,  $P<0.0001$ . However, no significant difference was observed regarding weight with MD= -1.81 (95%CI: -3.93, 0.31,  $P=0.09$ ) (Figures 3 and 4).

The use of cryolipolysis was also associated with decreased circumference of different body parts with MD= -3.45 (95%CI: -5.55, -1.34,  $P=0.001$ ), and  $I^2=92%$ ,  $P<0.00001$  and decreased fat thickness with MD= -3.56 (95%CI: -4.63, -2.48,  $P<0.00001$ ), and  $I^2=95%$ ,  $P<0.00001$  (Figures 5 and 6).

After subgroup analysis of different outcomes including BMI (subgroup by follow-up period), circumference (subgroup by body parts on which

Table 1: Baseline characteristics of the included studies

Study ID	Design	Sample size	Age, mean (SD)	Female, n (%)	Body parts	Follow-up
Choi (21)	A prospective, multicenter, single arm clinical trial	25	39.1 (11.6)	20 (80)	Abdomen	4 months
Coiante (20)	Prospective cohort	54	35 (13)	54 (100)	Abdomen	6 months
Eldesoky (17)	RCT	20	14 (70)	33.3 (5.33)	Abdomen	2 months
Khedmatgozar (22)	Non-randomized clinical trial	30	18-65	30 (100)	Abdomen	2 months
Loap (25)	Prospective cohort	30	36.72 (7)	30 (100)	Abdomen and Saddlebags	3 months
McKeown and Payne (24)	Prospective cohort	28	51.6 (9)	26 (93)	All body parts	3 months
Mostafa and Elshafey (23)	RCT	15	14 (1.9)	9 (60)	Abdomen	2 months
Savacini (18)	Prospective cohort	21	34 (9)	18 (85.7)	Abdomen and flanks	2 months
Wanitphakdeedecha (19)	Prospective cohort	20	>20	20 (100)	Arms and inner thigh	6 months
Zelickson (26)	Prospective cohort	42	48.1 (6.3)	42 (100)	Inner Thigh	4 months

RCT: randomized controlled trial, SD: standard deviation

Table 2: MINORS scale for quality assessment of the included studies

Study	I	II	III	IV	V	VI	VII	VIII	Total
Choi (21)	2	2	1	2	0	2	2	0	11
Coiante (20)	2	2	2	2	0	2	1	0	11
Khedmatgozar (22)	2	2	1	2	0	2	2	1	12
Loap (25)	2	2	2	2	1	1	2	0	12
McKeown and Payne (24)	2	1	1	2	0	2	2	0	10
Savacini (18)	2	1	2	2	0	2	2	0	11
Wanitphakdeedecha (19)	2	2	2	2	0	1	2	0	11
Zelickson (26)	2	2	2	2	0	1	2	0	11

Numbers I-VIII in the heading domains comprise: I, a clearly articulated objective; II, inclusion of consecutive patients; III, prospective data collection; IV, endpoints pertinent to the study's objective; V, impartial evaluation of the study endpoint; VI, follow-up duration suitable to the study's aim; VII, follow-up loss of less than 5%; VIII, prospective determination of the study size

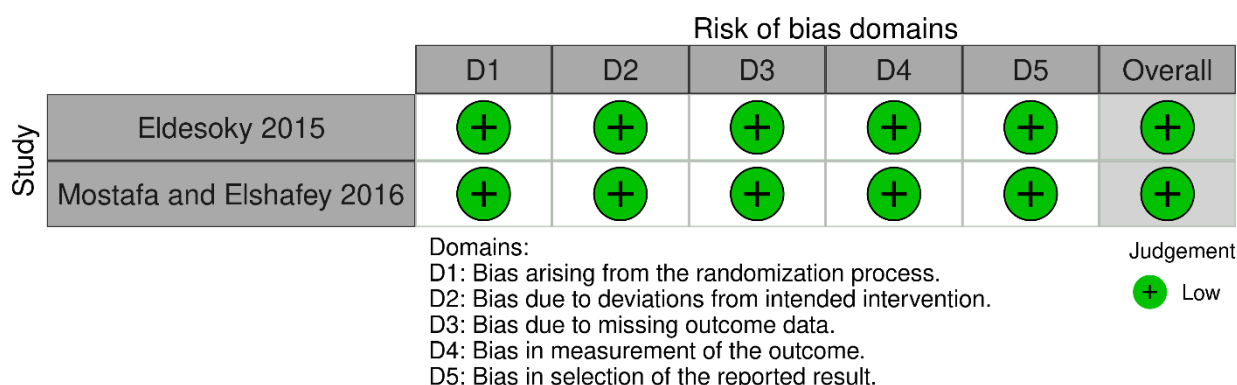


Figure 2: Risk of bias assessment of RCTs using Rob-2

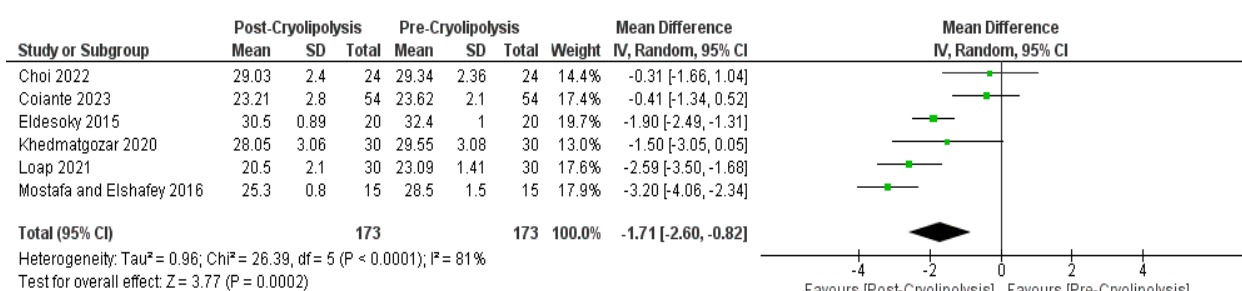


Figure 3: Effect of cryolipolysis on BMI

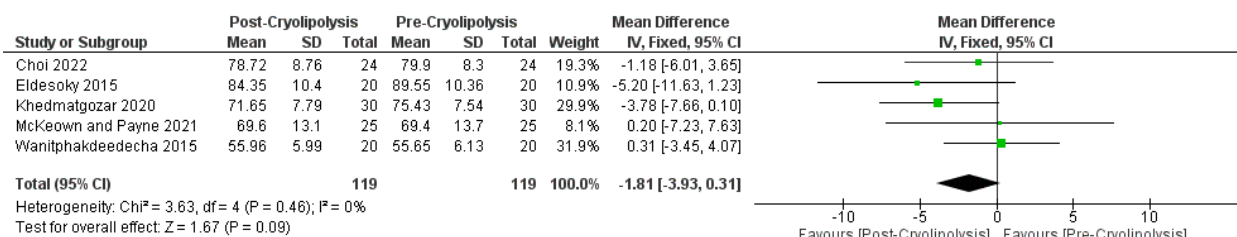


Figure 4: Effect of cryolipolysis on weight

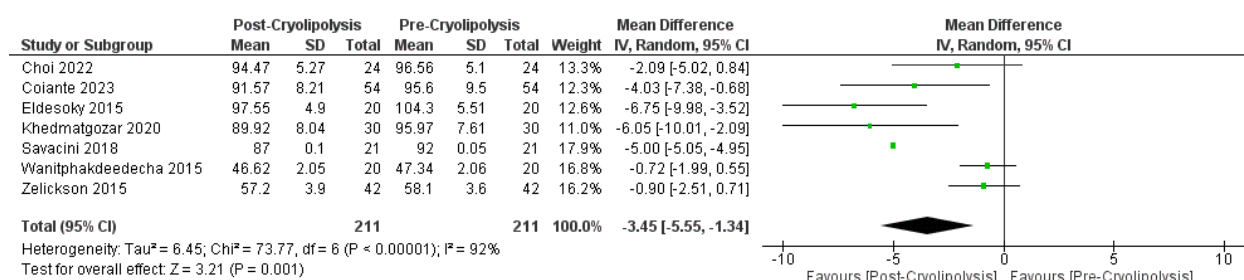


Figure 5: Effect of cryolipolysis on circumference of different body parts

cryolipolysis was applied), and fat thickness (subgroup by measurement method), the heterogeneity was resolved.

In the BMI, significant effect was observed in the follow-up period of less than or equal 3 months, however, after 3 months, the effect was non-

significant. Also, cryolipolysis showed significant effect on circumference of abdomen but non-significant effect on that of arms and inner thighs. Fat thickness measured by ultrasound or percentage was significantly reduced after cryolipolysis (Figures 7-9).

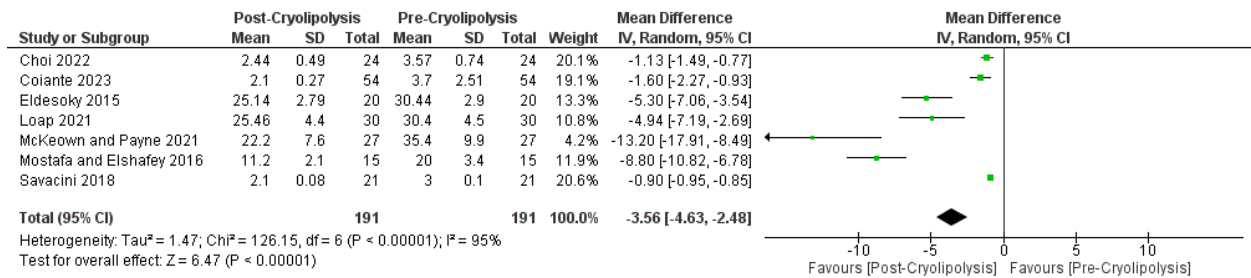


Figure 6: Effect of cryolipolysis on fat thickness

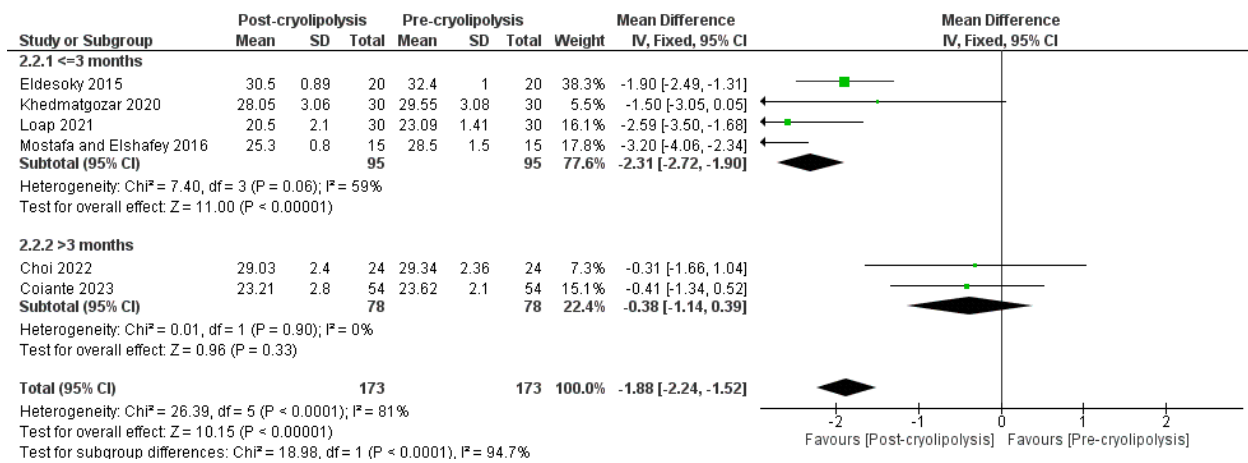


Figure 7: Effect of cryolipolysis on BMI subgrouped by follow-up period

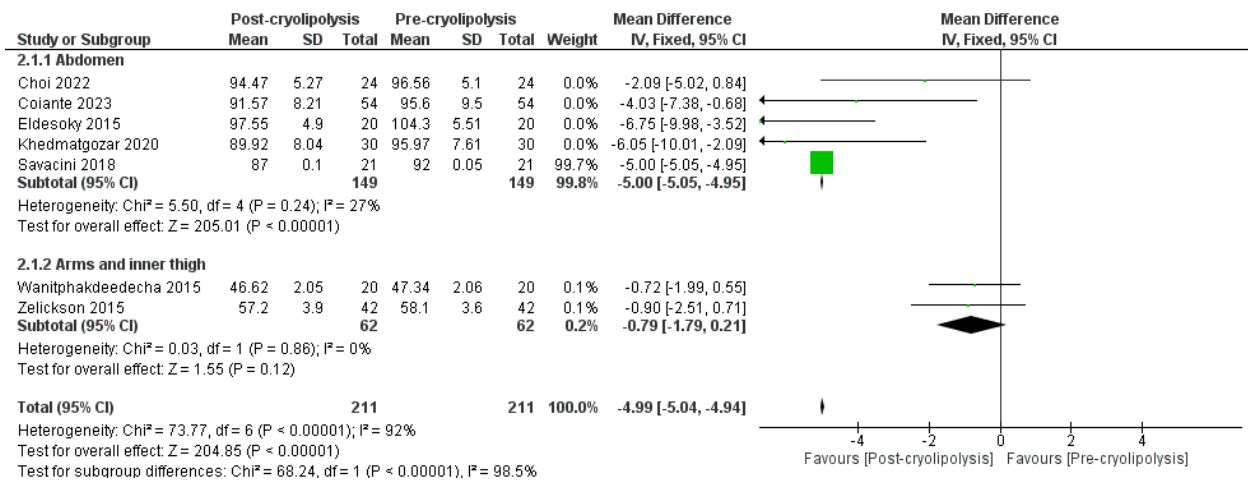


Figure 8: Effect of cryolipolysis on circumference of different body parts subgrouped by parts of cryolipolysis

## DISCUSSION

The current systematic review and meta-analysis showed the efficacy of cryolipolysis in the improvement of body contouring in obese patients. This was investigated among different body parts including the abdomen, flank, arms, and inner thighs. Cryolipolysis was observed to decrease BMI,

circumference of the measured body part, and the fat thickness or skinfold parts. On the other hand, no significant difference was observed on the weight of the included participants. Due to the observed heterogeneity, we conducted subgroup analysis based on follow-up period in BMI and found that the effect was evident when the follow-up was 3 or less than 3 months, but no effect was observed

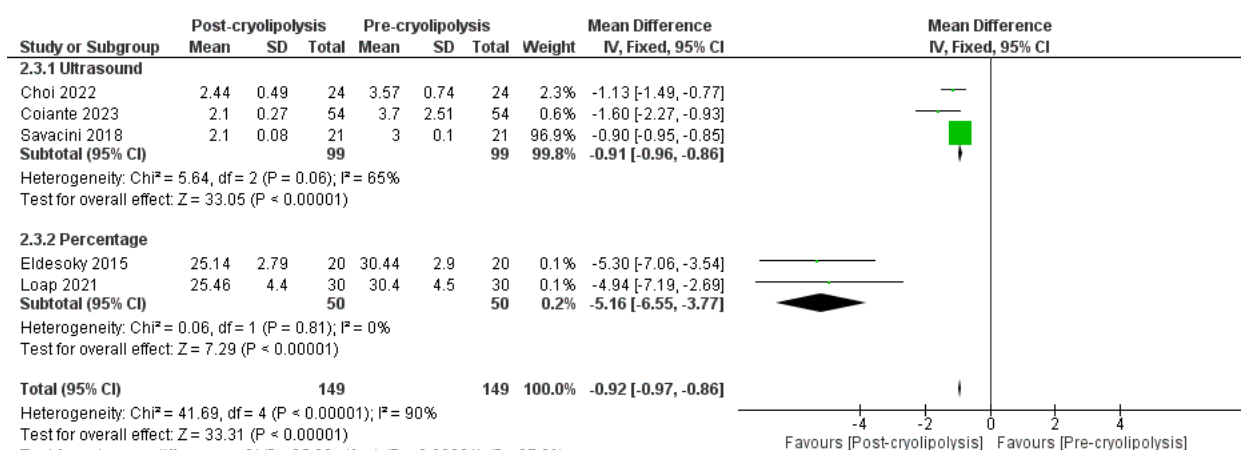


Figure 9: Effect of cryolipolysis on fat thickness subgrouped by measurement method

after more than 3 months. Subgroup analysis of circumference showed the effect was significant on the abdomen, but no effect was observed on the arms and inner thighs after cryolipolysis treatment. Fat thickness was significantly reduced when it was measured by ultrasound or percentage of fats.

Obesity has emerged as a significant public health issue, with projections indicating a prevalence of 50% among adults in the United States by 2030<sup>27</sup>. The increasing prevalence of obesity is not confined to developed nations but extends to emerging countries as well. Currently, the elevated average BMI historically observed in rich nations is being supplanted by that of less developed countries. Mercedes and Monika have indicated that nations with the highest average BMIs are primarily situated in Latin America, the Middle East, and North Africa, which exhibit the greatest global incidence of overweight individuals<sup>28</sup>. A cross-sectional study involving 3,799 individuals in Iran indicated that the prevalence of overweight and obesity was around 40.6% and 26.3%, respectively<sup>29</sup>. The rising incidence of overweight may be linked to lifestyle alterations, including insufficient physical activity, eating practices, and sedentary behaviors in these countries<sup>27, 30</sup>. In addition to educational initiatives and the implementation of incentives within socioeconomic situations, contemporary scientific evidence may prove advantageous to these individuals. Recently, non-invasive methods for adipose tissue reduction and body shape alteration are being increasingly employed<sup>31</sup>. Nonetheless, the health ramifications of these operations are not as well understood as those of invasive surgical interventions. These

non-invasive techniques encompass cryolipolysis, ultrasound, radiofrequency, low-level light laser, and mechanical suction, which are more time-efficient and devoid of the adverse effects associated with invasive surgery<sup>32</sup>; nevertheless, the clinical advantages require further clarification. Despite the introduction of several innovative technologies and techniques, cryolipolysis remains the most prevalent operation utilized in the US for this purpose<sup>33</sup>.

Cryolipolysis is a non-invasive technique for the reduction of subcutaneous adipose tissue. Initially designed for the cooling of medical devices, it is recognized for its efficacy in alleviating pain, reducing muscular spasms, and enhancing local circulation. It delivers regulated cooling energy to the targeted adipose tissue, effectively diminishing subcutaneous fat at the application location while preserving adjacent tissues<sup>7, 34</sup>. The mechanism of cryolipolysis was elucidated by Dr. Dieter Manstein and Dr. R. Rox Anderson, who demonstrated that exposure of subcutaneous adipose tissue to low temperatures induces local subcutaneous panniculitis, resulting in a reduction of fat tissue inside the affected lesions<sup>5, 34</sup>. Based on this idea, numerous investigations on subcutaneous fat reduction have been undertaken, leading to the development of cryolipolysis technology.

Numerous prior research have validated the effectiveness and safety of substantial subcutaneous fat loss in different body regions by cryolipolysis. Kilmer et al. verified an average reduction of 20% (2.0 mm) in subcutaneous fat behind the chin as observed through ultrasonography. The treatment parameters of this trial included two sessions, six-

week intervals, a treatment duration of 60 minutes, and a chilling temperature of -10 degrees Celsius<sup>35</sup>. Furthermore, other research findings corroborated the efficacy of submental cryolipolysis as assessed using ultrasonography or MRI<sup>36, 37</sup>. The rate of fat loss in flank and abdominal subcutaneous adipose tissue ranged from 20% to 25% according to efficacy evaluations utilizing ultrasonography, with the effects persisting for up to 6 months<sup>38, 39</sup>. The application of cryolipolysis to the thighs demonstrated a reduction of subcutaneous fat by 2.6 to 3.3 mm as validated by ultrasonography<sup>40, 41</sup>. Carruthers et al.<sup>42</sup> achieved a 3.2-mm reduction in the subcutaneous fat layer following the application of cryolipolysis to the upper arms. Park et al.<sup>43</sup> demonstrated that cryolipolysis applied to 10 male subjects with pseudogynecomastia resulted in a considerable reduction of breast adipose tissue post-treatment compared to pre-treatment levels. Following cryolipolysis, necrosis transpires in the targeted adipose tissue, resulting in the destruction of fat tissue. The damaged adipocytes trigger a wound-healing response that activates macrophages, leading to an inflammatory reaction. Macrophages diminish adipose tissue by metabolizing lipids and cellular detritus from adipocytes in the liver via the lymphatic system 14 to 30 days post-procedure. Consequently, this process may result in fat cell remnants, including lipids and cellular debris, influencing blood composition and liver function. Klein et al. established that there were no significant variations in blood lipid levels and liver function test outcomes pre- and post-cryolipolysis<sup>5, 7, 44</sup>. Complications of cryolipolysis include post-procedural dyschromia, characterized by hypopigmentation or hyperpigmentation<sup>45-48</sup>. Dyschromia predominantly manifested in patients with a darker skin phototype (Fitzpatrick type III/IV) and resolved after several months<sup>49</sup>. Burns and hemosiderin deposits in the dermis are responsible for hyperpigmentation<sup>50-55</sup>. The implementation of an interposed layer may reduce the probability of this difficulty. Prior to performing cryolipolysis, patients must be apprised of the potential consequences, including hyperpigmentation or erythema, which typically manifest approximately 15 hours post-procedure. The likelihood of skin lesions is negligible in comparison to liposuction, which consistently results in considerable post-operative bruising and discomfort because of too

thin subcutaneous hematomas. Patients must be informed and provide consent regarding the danger of paradoxical adipose hyperplasia, which occurs in one in 20,000 treated individuals (an incidence rate of 0.0051%). Nonetheless, the long-term danger of acquiring skin lesions remains uncertain<sup>56</sup>. Cryolipolysis is contraindicated in individuals with Raynaud's Syndrome, cryoglobulinemia, cold urticaria, or severe varicose veins exacerbated by low temperatures.

Nonetheless, we wish to underscore that cryolipolysis cannot serve as a substitute for a comprehensive abdominoplasty when indicated. Moreover, as of yet, the actual risk of developing skin lesions (permanent hyperpigmentation or erythema) in the long run remains unknown. It is imperative to highlight that, when abdominoplasty is indicated, this procedure should be avoided, as it is well-established that abdominoplasty becomes significantly more challenging following this type of treatment due to the degree of post-treatment fibrosis<sup>48</sup>. The distinction between cryolipolysis and alternative techniques, such as high-intensity focused ultrasound, primarily lies in the significantly lower cost each session, the lack of required consumables, and the completely painless experience throughout the procedure. Indeed, a side effect of cold is the local anesthetic it induces; thus, the primary distinction from high-intensity focused ultrasound is that patients undergoing cryolipolysis report no pain or discomfort during the procedure. The current study is limited by the observational and non-randomized design of most of the included studies and absence of control or placebo group as a comparator. Therefore, future RCTs are required to include a comparator group and the specification of different body parts is also recommended in future trials.

## CONCLUSION

The current comprehensive review and meta-analysis revealed the efficacy of cryolipolysis in improving body contouring in obese persons. This evaluation included multiple anatomical areas, such as the abdomen, flanks, arms, and inner thighs. Cryolipolysis led to decreases in BMI, circumferences of the targeted regions, and fat thickness or skinfold measures. No substantial alteration in participants' weight was observed. A

subgroup analysis of BMI was conducted depending on follow-up time, demonstrating a significant effect within three months or less, with no effect identified beyond that period. The subgroup analysis for circumference revealed a considerable impact on the belly, but no effect was observed on the arms and inner thighs following cryolipolysis treatment. Fat thickness demonstrated a notable decrease when evaluated using ultrasonography or fat percentage assessments.

## ACKNOWLEDGMENTS

No financial source was received for this study.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interests.

## REFERENCES

- Pinto H. Local fat treatments: classification proposal. *Adipocyte* 2016;5(1):22-6.
- Amir R, Rosenberg A, Dubitsky D, Nahshon G, Nachlieli T. A novel high power bipolar RF technology for non invasive body contouring. *Journal Of The American Academy Of Dermatology*; 2011: Mosby-Elsevier 360 Park Avenue South, New York, NY 10010-1710 USA; 2011. p. AB2-AB.
- Coleman KM, Coleman WP, 3rd, Benchetrit A. Non-invasive, external ultrasonic lipolysis. *Semin Cutan Med Surg* 2009 Dec;28(4):263-7.
- Jalian HR, Avram MM. Body contouring: the skinny on noninvasive fat removal. *Semin Cutan Med Surg* 2012 Jun;31(2):121-5.
- Manstein D, Laubach H, Watanabe K, Farinelli W, Zurakowski D, Anderson RR. Selective cryolysis: a novel method of non-invasive fat removal. *Lasers Surg Med* 2008 Nov;40(9):595-604.
- Nelson AA, Wasserman D, Avram MM. Cryolipolysis for reduction of excess adipose tissue. *Semin Cutan Med Surg* 2009 Dec;28(4):244-9.
- Avram MM, Harry RS. Cryolipolysis for subcutaneous fat layer reduction. *Lasers Surg Med* 2009 Dec;41(10):703-8.
- Zelickson B, Egbert BM, Preciado J, et al. Cryolipolysis for noninvasive fat cell destruction: initial results from a pig model. *Dermatol Surg* 2009 Oct;35(10):1462-70.
- Shek SY, Chan NP, Chan HH. Non-invasive cryolipolysis for body contouring in Chinese--a first commercial experience. *Lasers Surg Med* 2012 Feb;44(2):125-30.
- Klein KB, Zelickson B, Riopelle JG, et al. Non-invasive cryolipolysis for subcutaneous fat reduction does not affect serum lipid levels or liver function tests. *Lasers Surg Med* 2009 Dec;41(10):785-90.
- Stevens WG, Pietrzak LK, Spring MA. Broad overview of a clinical and commercial experience with CoolSculpting. *Aesthet Surg J* 2013 Aug 1;33(6):835-46.
- Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ* 2009;339:b2535.
- Rayyan. [cited; Available from: <https://rayyan.ai/>]
- Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019 Aug 28;366:l4898.
- Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (minors): development and validation of a new instrument. *ANZ J Surg* 2003 Sep;73(9):712-6.
- RevMan: Systematic review and meta-analysis tool for researchers worldwide | Cochrane RevMan. [cited; Available from: <https://revman.cochrane.org/info>]
- Mahmoud ELdesoky MT, Mohamed Abutaleb EE, Mohamed Mousa GS. Ultrasound cavitation versus cryolipolysis for non-invasive body contouring. *Australas J Dermatol* 2016;57(4):288-93.
- Savacini MB, Bueno DT, Molina ACS, et al. Effectiveness and Safety of Contrast Cryolipolysis for Subcutaneous-Fat Reduction. *Dermatol Res Pract* 2018;2018:5276528.
- Wanitphakdeedecha R, Sathaworawong A, Manuskiatti W. The efficacy of cryolipolysis treatment on arms and inner thighs. *Lasers Med Sci* 2015 Nov;30(8):2165-9.
- Coiante E, Pensato R, Hadji I, et al. Assessment of the Efficacy of Cryolipolysis on Abdominal Fat Deposits: A Prospective Study. *Aesthetic Plast Surg* 2023 Dec;47(6):2679-86.
- Choi SY, Park JW, Koh YG, et al. Cryolipolysis for abdominal subcutaneous fat reduction: A prospective, multicenter, single arm, clinical study. *Dermatol Ther* 2022 Sep;35(9):e15717.
- Khedmatgozar H, Yadegari M, Khodadadegan MA, et al. The effect of ultrasound cavitation in combination with cryolipolysis as a non-invasive selective procedure for abdominal fat reduction. *Diabetes Metab Syndr* 2020 Nov-Dec;14(6):2185-9.
- Mostafa MS, Elshafey MA. Cryolipolysis versus laser lipolysis on adolescent abdominal adiposity. *Lasers Surg Med* 2016 Apr;48(4):365-70.
- McKeown DJ, Payne J. Significant improvement in body contour with multiple cycles of CoolSculpting:

- Results of a prospective study. *Dermatol Ther* 2021 Mar;**34**(2):e14850.
25. Suvaddhana Loap S, SidAhmed-Mezi M, Meningaud JP, Hersant B. A Prospective, Comparative Study (before and after) for the Evaluation of Cryothermogenesis' Efficacy in Body Contouring: Abdomen and Saddlebags. *Plast Reconstr Surg* 2022 Mar 1;**149**(3):424e-8e.
  26. Zelickson BD, Burns AJ, Kilmer SL. Cryolipolysis for safe and effective inner thigh fat reduction. *Lasers Surg Med* 2015 Feb;**47**(2):120-7.
  27. Wang Y, Beydoun MA, Min J, Xue H, Kaminsky LA, Cheskin LJ. Has the prevalence of overweight, obesity and central obesity levelled off in the United States? Trends, patterns, disparities, and future projections for the obesity epidemic. *Int J Epidemiol* 2020 Jun 1;**49**(3):810-23.
  28. de Onis M, Blössner M. Prevalence and trends of overweight among preschool children in developing countries. *Am J Clin Nutr* 2000 Oct;**72**(4):1032-9.
  29. Rashidy-Pour A, Malek M, Eskandarian R, Ghorbani R. Obesity in the Iranian population. *Obes Rev* 2009 Jan;**10**(1):2-6.
  30. Bhurosy T, Jeewon R. Overweight and obesity epidemic in developing countries: a problem with diet, physical activity, or socioeconomic status? *ScientificWorldJournal* 2014;**2014**:964236.
  31. Mazzoni D, Lin MJ, Dubin DP, Khorasani H. Review of non-invasive body contouring devices for fat reduction, skin tightening and muscle definition. *Australas J Dermatol* 2019 Nov;**60**(4):278-83.
  32. Nassab R. The evidence behind noninvasive body contouring devices. *Aesthet Surg J* 2015 Mar;**35**(3):279-93.
  33. Widgerow AD, Moradi A, Poehler J. A Double-Blind Randomized Controlled Trial Evaluating the Efficacy and Tolerability of a Topical Body Treatment in Combination With Cryolipolysis Procedures. *J Drugs Dermatol* 2019 Apr 1;**18**(4):342-8.
  34. Alizadeh Z, Halabchi F, Mazaheri R, Abolhasani M, Tabesh M. Review of the Mechanisms and Effects of Noninvasive Body Contouring Devices on Cellulite and Subcutaneous Fat. *Int J Endocrinol Metab* 2016 Oct;**14**(4):e36727.
  35. Kilmer SL, Burns AJ, Zelickson BD. Safety and efficacy of cryolipolysis for non-invasive reduction of submental fat. *Lasers Surg Med* 2016 Jan;**48**(1):3-13.
  36. Suh DH, Park JH, Jung HK, Lee SJ, Kim HJ, Ryu HJ. Cryolipolysis for submental fat reduction in Asians. *J Cosmet Laser Ther* 2018 Feb;**20**(1):24-7.
  37. Bernstein EF, Bloom JD. Safety and Efficacy of Bilateral Submental Cryolipolysis With Quantified 3-Dimensional Imaging of Fat Reduction and Skin Tightening. *JAMA Facial Plast Surg* 2017 Sep 1;**19**(5):350-7.
  38. Garibyan L, Sipprell WH, 3rd, Jalian HR, Sakamoto FH, Avram M, Anderson RR. Three-dimensional volumetric quantification of fat loss following cryolipolysis. *Lasers Surg Med* 2014 Feb;**46**(2):75-80.
  39. Dover J, Burns J, Coleman S, et al. A prospective clinical study of noninvasive cryolipolysis for subcutaneous fat layer reduction—Interim report of available subject data. *Lasers Surg Med* 2009;**41**(S21):43.
  40. Boey GE, Wasilenchuk JL. Fat reduction in the inner thigh using a prototype cryolipolysis applicator. *Dermatol Surg* 2014 Sep;**40**(9):1004-9.
  41. Stevens WG, Bachelor EP. Cryolipolysis conformable-surface applicator for nonsurgical fat reduction in lateral thighs. *Aesthet Surg J* 2015 Jan;**35**(1):66-71.
  42. Carruthers JD, Humphrey S, Rivers JK. Cryolipolysis for Reduction of Arm Fat: Safety and Efficacy of a Prototype CoolCup Applicator With Flat Contour. *Dermatol Surg* 2017 Jul;**43**(7):940-9.
  43. Park JT, Kwon SH, Shin JW, Park KC, Na JI, Huh CH. The efficacy and safety of cold-induced lipolysis in the treatment of pseudogynecomastia. *Lasers Surg Med* 2016 Aug;**48**(6):584-9.
  44. Fatemi A, Kane MA. High-intensity focused ultrasound effectively reduces waist circumference by ablating adipose tissue from the abdomen and flanks: a retrospective case series. *Aesthetic Plast Surg* 2010 Oct;**34**(5):577-82.
  45. Adjadj L, SidAhmed-Mezi M, Mondoloni M, Meningaud JP, Hersant B. Assessment of the Efficacy of Cryolipolysis on Saddlebags: A Prospective Study of 53 Patients. *Plast Reconstr Surg* 2017 Jul;**140**(1):50-7.
  46. Lipner SR. Cryolipolysis for the treatment of submental fat: Review of the literature. *J Cosmet Dermatol* 2018 Apr;**17**(2):145-51.
  47. Hwang IC, Kim KK, Lee KR. Cryolipolysis-induced abdominal fat change: Split-body trials. *PLoS One* 2020;**15**(12):e0242782.
  48. Falster M, Schardong J, Santos DPD, et al. Effects of cryolipolysis on lower abdomen fat thickness of healthy women and patient satisfaction: a randomized controlled trial. *Braz J Phys Ther* 2020 Sep-Oct;**24**(5):441-8.
  49. Meyer PF, Davi Costa ESJ, Santos de Vasconcellos L, de Moraes Carreiro E, Valentim da Silva RM. Cryolipolysis: patient selection and special considerations. *Clin Cosmet Investig Dermatol* 2018;**11**:499-503.
  50. La Padula S, Hersant B, Chatel H, et al. One-step facial feminization surgery: The importance of a custom-made preoperative planning and patient satisfaction assessment. *J Plast Reconstr Aesthet Surg* 2019 Oct;**72**(10):1694-9.

51. Hersant B, SidAhmed-Mezi M, Aboud C, et al. Synergistic Effects of Autologous Platelet-Rich Plasma and Hyaluronic Acid Injections on Facial Skin Rejuvenation. *Aesthet Surg J* 2021 Jun 14;41(7):Np854-np65.
52. Meningaud JP, SidAhmed-Mezi M, Billon R, Rem K, La Padula S, Hersant B. Clinical benefit of using a multifractional Er:YAG laser combined with a spatially modulated ablative (SMA) module for the treatment of striae distensae: A prospective pilot study in 20 patients. *Lasers Surg Med* 2019 Mar;51(3):230-8.
53. La Padula S, Hersant B, Bompoy L, Meningaud JP. In search of a universal and objective method to assess facial aging: The new face objective photo-numerical assessment scale. *J Craniomaxillofac Surg* 2019 Aug;47(8):1209-15.
54. Ruiz R, Hersant B, La Padula S, Meningaud JP. Facelifts: Improving the long-term outcomes of lower face and neck rejuvenation surgery: The lower face and neck rejuvenation combined method. *J Craniomaxillofac Surg* 2018 Apr;46(4):697-704.
55. La Padula S, Hersant B, Pizza C, et al. Striae distensae: in vitro study and assessment of combined treatment with sodium ascorbate and platelet-rich plasma on fibroblasts. *Aesthetic Plastic Surgery* 2021;45:1282-93.
56. Ingargiola MJ, Motakef S, Chung MT, Vasconez HC, Sasaki GH. Cryolipolysis for fat reduction and body contouring: safety and efficacy of current treatment paradigms. *Plast Reconstr Surg* 2015 Jun;135(6):1581-90.