# The effect of combination of red, infrared and blue wavelengths of Low Level Laser on reduction of abdominal girth circumference: a before - after case series

Katayoon Montazeri1, Soheila Mokmeli2

1Laboratory for Auditory Neuroscience, ENT and Head & Neck Research Centre, Iran University of Medical Sciences, Tehran, Iran

Phone: +98 21 66504294, Fax: +98 21 66525329

2Canadian Optic and Laser Center (COL Center), Research Unit, Victoria BC Canada

Phone: 2504807867

Katayoon Montazeri: M.D, E-mail address: [katayoon\_mon@yahoo.com](mailto:katayoon_mon@yahoo.com)

Soheila Mokmeli: Research Manager, MD, Laser Therapy Practitioner, Laser Therapy Instructor, E-mail address: [dr.mokmeli@yahoo.com](mailto:dr.mokmeli@yahoo.com)

**Corresponding author**: katayoon Montazeri

**Reviewer**: Jan Tunér; Mailing address: Spjutvagen 11,77232Grangresberg, Sweden

E mail:[jan.tuner@swipnet.se](mailto:jan.tuner@swipnet.se)

Education: DDS degree, Faculty of Dentistry, Karolinska Institutet, Stockholm, 1968

Clinical experience: Public and government services: 1968-1973, Private practice: 1973 - Present

Professional positions: General Manager, Prima Books AB, Sweden, President, Dala Dental AB, Sweden

**Abstract**

**Background and Objective:** The objective of this study was to assess the efficacy of a combination of three wavelengths (including red, infra-red, and blue) of low-level laser (LLL) as a non-invasive therapeutic method for reducing abdominal girth circumference. To achieve the biochemical activity on adipocytes, a red laser was used in our selective laser combination. Near-infrared laser was used to increase the depth of penetration. Nitrosyl complexes of hemoglobin (NO-Hb) are sensitive to blue light, thereby leading to increase in the release of biologically active nitric oxide (NO), which can affect tissue perfusion. Thus, a blue LED was added to the laser combination.

**Materials and Methods:** Eighteen females participated in the study. Twelve sessions of laser therapy were performed, two sessions per week for each subject. Continuous wave diode lasers, including red (630 nm), infra-red (808 nm), and a blue LED (450 nm), were applied and were all designed by the Canadian Optic and Laser Center.

**Results:** Statistical analyses revealed that upper abdomen size significantly decreased from pre- (91.86 ± 11.16) to post- (87.41 ± 10.52) low level laser therapy (LLLT) (p<0.001). Middle abdomen size showed significant reduction from pre- (97.02 ± 8.82) to post- (91.97 ± 8.49) LLLT (p<0.001). Lower abdomen size significantly decreased from pre- (100.36 ± 9.45) to post- (95.80 ± 8.52) LLLT (p<0.001).

**Conclusion:** Here, based on this case series pilot investigation, this study reports a combination of 3 different wavelengths of LLL, to be effective in 100% of our subjects (p<0.001) without any side effects.

**Key words:** Diode lasers, low level laser therapy, non-invasive girth reduction.

**Introduction**

The term cellulite (also known as gynoid lipodystrophy and adiposis edematosa) refers to the herniation of subcutaneous fat within fibrous connective tissue that manifests as skin uneven dimpling or “orange peel” appearance.1,2,3 Cellulite is more common on the buttocks, lower limbs, and abdomen.1,2 Cellulite affects mainly women as a result of “differences in the structural anatomy of subcutaneous tissue in women and the possible influence of estrogen”.4 The prevalence of cellulite in post-adolescent females was estimated to be between 80 and 90%3,5 which led to the development of cosmetic complications. Cellulite appears to be a “multifactorial disorder”4 which is likely due to metabolic alterations, changes in lymphatic and vascular microcirculation, dieting too hard or too much, sex-specific dimorphic, skin architecture, alteration of connective tissue structure, and hormonal and genetic factors.1,5,6,7 Enzo Emanuele et al3 traced “the genetic component of cellulite to particular polymorphisms in the angiotensin converting enzyme (ACE) and hypoxia-inducible factor 1A (HIF1a) genes”.

There are various modalities in the treatment of localized subcutaneous fat deposits (massage or mechanical manipulation, mesotherapy, bipolar radiofrequency, liposuction, laser lipolysis, etc.), but empirical evidence for the efficacy of these strategies is limited.3

Low-level laser therapy is a non-thermal, non-invasive technique which is practiced by physicians and laser therapists for a wide variety of diseases. It is used for tissue regeneration and bio-stimulation, decreasing pain, swelling, and inflammatory response in orthopedic injuries and degenerative diseases, wound healing, and numerous cosmetic procedures such as breast augmentation and lipoplasty.8,9,10,11 It is used as an adjunct to liposuction to reduce pain and inflammation11 and it has also been shown to be effective for non-invasive body contouring. Reduction in cholesterol and leptin levels are other significant clinical benefits of LLLT which was reported in several studies.12, 13

United States Food and Drug Administration (FDA) approved the clinically tested low-level laser ZERONA® device as a “non-invasive dermatological aesthetic treatment for the circumferential reduction of hips, waist, and thighs”.

The mechanism of action of laser irradiation on non-invasive body contouring and cellulite reduction remains somewhat controversial. LLLT was suggested to induce the formation of transitory micro-pores in the cell membrane of adipocytes, allowing intracellular lipids to leak out14,15,16,17. Although, the biochemical mechanism of action of LLLT on adipose tissue is still controversial, one possible explanation might be that, absorption of laser light by mitochondrial chromophores (particularly, cytochrome C oxidase) of the adipocytes led to the increase of cyclic adenosine monophosphate (cAMP) production. Elevated cAMP stimulates cytoplasmic lipase, an enzyme that converts triglycerides into fatty acids and glycerol which can both pass through transitory pores, thereby, leading to shrinkage of the adipocytes14, 15, 16.

The ability of low level laser for non-invasive body contouring has been investigated by many researchers. Coleman et al. (1998) reported 18% reduction in the thickness of subcutaneous fat of the buttocks and thighs of 10 participants after irradiation with 623 and 904 nm lasers.17,18, 19 Lach and Pap (2004) conducted another study among 25 subjects who underwent a series of treatments with infrared and red lasers, followed by massage. In total, 14 subjects showed a 5 to 35% reduction in fat thickness and improvement in the appearance of cellulite in the thighs at the end of the treatment period.20 Bourassa (2007) investigated the action of 630 - 680 nm, 150 mW showering arrays, and single 40 mW diode laser irradiation sources on 311 participants. A total of 130 patients in groups of 6 and 12 sessions achieved average sustained losses of 6.55 and 11.04 cm, corresponding to an average girth reduction of 0.48 to 0.55 cm per session.21

A review of the studies which applied LLLT for body contouring revealed that some researchers used red laser alone21, 22, 23, 24, 25,26 and others used a combination of red and infra-red lasers. 17, 19, 20

In this study, a combination of three different wavelengths of diode lasers was used and the effects of this combination were investigated on abdominal girth reduction.

Lasers were selected according to the findings of several researches as subsequently discussed.

Neira et al. (2002) investigated the action of red laser (635 nm, 10 mw intensity) on human adipocytes taken from lipectomy samples. Transmission electron microscope (TEM) and scanning electron microscope (SEM) images revealed the formation of transient micro-pores in cell membrane of the adipocytes. Subsequently, up to 99% of fat could be released from the adipocytes leading to complete deflation of adipocytes.18, 19 Another proposed mechanism of action is based upon activation of complement cascade which could induce adipocyte apoptosis leading to release of lipids through transient pores. 11 A red 630 nm laser was used in our selective lasers combination to achieve this biochemical activity on adipocytes.

It was shown by several studies that penetration depth is significantly affected by wavelength. Longer wavelengths will penetrate further because both scattering and absorption of light is higher in shorter wavelengths. 27, 28, 29, 30  There is a so-called therapeutic window (also known as optical window) which defines the range of wavelengths from 650 to 1350 nm where the effective tissue penetration of light is maximized30. A near-infrared laser (808 nm) was used for affecting deeper fat layers.

On the other hand, Furchgot (1968) demonstrated the ability of laser light to facilitate the release of nitric oxide (NO) from nitrosyl complexes of hemoglobin. Biologically active NO can stimulate vasodilation through the effect of NO on cGMP followed by increasing blood circulation in the tissue.31, 32, 33 It has recently been shown that the most effective wavelengths on light mediated release of NO are UV-A (320 to 400 nm) and blue range (400 to 460 nm). 31, 32, 33, 34, 35 One of the cellulite predisposing factors is circulatory insufficiency. 1, 5, 6,7 Over this fact, ameliorating tissue perfusion by blue light may be effective for decreasing problems of circulation and reducing localized adiposity.

The experimental objective of this study, therefore, was to evaluate the application of a 630 nm red laser, 808 nm infra-red laser, and a 450 nm blue LED (blue laser was not available) for non-invasive reduction of circumference in patients with abdominal localized adiposity.

## Materials and methods

This study was designed as a before-after case series. Eighteen adult females aged between 26 and 62 years with abdominal localized adiposity received 12 biweekly treatments. Mean age ± standard deviation = 44.61 ± 10.98.

Subjects were selected according to the following exclusion and inclusion criteria:

Inclusion criteria comprised female gender patients who did not respond to diet and exercise, willingness to abstain from participating in any other treatment procedures for weight loss and girth reduction during the course of study, willing and able to maintain normal pre-study diet and exercise, and age between 20 and 65 years.

Exclusion criteriaincluded body mass index (BMI) of 30 kg/m² or above, diabetes mellitus, cardiovascular disease, prior surgical interventions for body contouring or weight loss, current use of medication(s) known to affect weight levels and/or cause bloating or swelling, pregnancy, breast feeding, and serious mental health illness.

This study was conducted in our private medical laser clinic, Tehran, Iran, between April 2013 and January 2014.

Approval was received from the ethics committee of Iranian Medical Laser Association and all subjects signed the informed consent form and satisfied all the study eligibility criteria.

Laser devices used included red laser designed by Canadian optic and laser (COL) company, 630 nm, 100 mw, spot size=1 cm2; continuous mode, power density = 0.1 W/cm2; Infra-red laser designed by COL company, 808 nm, 100 mw, spot size = 1 cm2; continuous mode, power density = 0.1 W/cm2; Blue LED designed by COL company, 450 nm, 3000 mw, spot size = 1 cm2.

The three wavelengths were applied sequentially, first infrared laser, followed by red laser, and then blue LED. The time of irradiation of each laser device was manually controlled by a timer. The laser devices were calibrated automatically. The assessment tool was a plastic scale tool and a single assessor was used for the measurements before and after LLLT.

Each laser device was administered on 10 points of each quadrant of the abdomen. The first point which was 3 cm apart from the umbilicus was chosen and then 3 cm apart laser device was used from one treatment point to another. Laser device was positioned at contact mode with a moderate pressure on tissue and titled at a 90º angle. Time of irradiation was 15 s per point for each device (1.5 Joule per point IR + 1.5 Joule per point red + 45 Joule per point the blue LED, in total 48 Joule IR + RED + Blue LED per point). Total energy was 480 Joule per quadrant and 1920 Joule per session. The umbilicus was used as an anatomical landmark to differentiate parts of the abdomen for measurements. Girth of the abdomen at the site of umbilicus was noted as the middle abdomen and the girth of 4 cm above the umbilicus was measured as the upper abdomen and 4 cm below the umbilicus was measured as the lower abdomen. The before and after evaluation was made only by measurement and abdominal girths were measured before the beginning of LLLT and after completion of the therapy (Table 1).

Unfortunately, only few of the patients took part in the follow up measurement after 3 months and because the number of clients was not enough, follow-up reports were skipped.

No adverse events were reported during the study procedure. Some of the participants who suffered from constipation reported amelioration after 3 or 4 sessions of LLLT.

# Results:

A paired t-test was used to compare sizes of the upper, middle, and lower abdomen pre- to post-LLLT. Statistical analyses revealed that upper abdomen size significantly decreased from pre- (91.86 ± 11.16) to post- (87.41 ± 10.52) LLLT (p<0.001). Middle abdomen size showed significant reduction from pre- (97.02 ± 8.82) to post- (91.97 ± 8.49) LLLT (p<0.001). Lower abdomen size significantly decreased from pre- (100.36 ± 9.45) to post- (95.80 ± 8.52) LLLT (p<0.001) (Table 2).

Mean differences comparing the reduction in mean sizes of upper, middle and lower abdomen pre- to post- LLLT were -4.81±2.31 for upper abdomen, -4.87±4.20 for middle abdomen and -4.12±1.66 for lower abdomen (Table 3).

**Discussion**

The results of this study show that LLLT using three different wavelengths of diode lasers is an effective and safe method for reducing girth circumference.

Apparently, to assess the effectiveness of the combination of these wavelengths to each one of them alone, there should have been at least 5 study groups: red laser alone, infrared laser alone, blue LED alone, red and infrared, and the combination of the 3 wavelengths. This research was undertaken with a before-after case series as a pilot study. It was accepted that this case series cannot be used as a clinical reference. A multi-groups clinical trial is the next plan for further investigation on this category.

**Conclusion**

LLLT is a safe, non-invasive and pain free technique, which is effective for reducing local adiposity. Here, based on this case series pilot investigation, this study reports a combination of 3 different wavelengths, to be effective in 100% of our subjects (p<0.001) without any side effects. But it was accepted that there is a need for large sample size and placebo/control groups. The next step is to investigate this combination of wavelengths in a clinical case/control groups study.

**Conflict of interest**

The authors have no conflict of interest to declare.

## References:

1. Rossi AB, Vergnanini AL. "Cellulite: a review". J Eur Acad Dermatol Venereol 14 (4): July 2000. 251–62. doi:10.1046/j.1468-3083.2000.00016.x. PMID 11204512.

2. PINNA K. "Nutrition and diet therapy". 2007. Belmont, CA: Wadsworth. p.178

3. Emanuele E., Bertona, M., andGeroldi, D. "A multilocus candidate approach identifies ACE and HIF1A as susceptibility genes for cellulite". Journal of the European Academy of Dermatology and Venereology 24 (8): 930–5.2010. doi:10.1111/j.1468-3083.2009.03556.x. PMID 20059631.

4- Robert F. Jackson, Gregory C. Roche, Steven C. Shanks "double-blind, placebo-controlled randomized trial evaluating the ability of low-level laser therapy to improve the appearance of cellulite". Lasers in Surgery and Medicine, Volume 45, Issue 3, pages 141–147. March 2013.

5. Wanner, M., and Avram, M. "An evidence-based assessment of treatments for cellulite". J Drugs Dermatol 7 (4): 341–5. April 2008. PMID 18459514.

6. Pavicic, T., Borelli C, Korting HC "Cellulite--the greatest skin problem in healthy people?An approach". J Dtsch Dermatol Ges (in German) 4 (10): 861–70. doi:10.1111/j.1610-0387.2006.06041.x. October 2006. PMID 17010177.

7. Terranova, F., Berardesca, E., and Maibach, H. "Cellulite: nature and aetiopathogenesis". Int J Cosmet Sci 28 (3): 157–67. June 2006. doi:10.1111/j.1467-2494.2006.00316.x. PMID 18489272.

8. Mulholland RS. , Paul, M., Chalfoun, C. "Noninvasive body contouring with radiofrequency, ultrasound, cryo-lipolysis, and low-level laser therapy".Clin Plastic Surg. 38:503–520. 2011.

9. Jackson, R., Roche, G., Butterwick, JK. et al. " Low level laser-assisted liposuction: clinical trial of its effectiveness for enhancing ease of liposuction procedures and facilitating the recovery process for patients undergoing thigh, hip and stomach contouring. Am J Cosmet Surg. 2004.

10. Maloney, R., Shanks, S. and Jenney, E. "The reduction in cholesterol and triglyceride serum levels following low-level laser irradiation: a non-controlled, non-randomized pilot study". Laser Srug Med.21S:66. 2009.

11. Avci P, et al. "Low-Level Laser Therapy for Fat Layer Reduction: A Comprehensive Review". 2013; doi: 10. 1002/lsm.22153

12. Jackson FR, Roche GC, Wisler K. "Reduction in cholesterol and triglycerides serum levels following low level laser irradiation: A noncontrolled, nonrandomized pilot study". Am J Cosmet Surg. 2010; 27(4):177- 184.

13. Rushdi AT." Effect of low-level laser therapy on cholesterol and triglyceride levels in ICU patients: A controlled randomized study". EJCTA;4:96-99. 2010.

14. Karu, TI. "Mitochondrial signaling in mammalian cells activated by red and near-IR radiation". Photochem Photobiol. 2008. 84:1091–1099.

15. Karu, TI. " Photobiology of low-power laser effects". Health Phys. 1989. 56:691–704.

16. Karu, TI., Afanasyeva, NI. "Cytochrome C oxidase as primary photo acceptor for cultured cells in visible and near IR regions. DokladyAkadNauk (Moscow) 342:693–695. 1995.

17. Rosenbaum, M., Prieto, V., Hellmer, J. et al. "An exploratory investigation of the morphology and biochemistry of cellulite".PlastReconstrSurg. 1998. 101:1934–9.

18. Neira, R., Arroyave, J., Ramirez, H., et al. " Fat liquefaction: effect of low level laser energy on adipose tissue". Plast Reconstr Surg. 110:912–922. 2002. doi: 10.1097/00006534-200209010-00030.

19. Lucassen, GW, et al. "The effectiveness of massage treatment on cellulite as monitored by ultrasound imaging". Skin Res Technol. 3:154–60. 1999.

20. Lach, E., Pap, S. " Laser treatment for cellulite: A non-invasive alternative to liposuction". Lasers Surg Med. 34, S16–32. 2004.

21. Daniel, J. Bourassa.et al. "DCA population within a species that has distinct genetic variation"; as published at: [www.ChiroEco.com](http://www.ChiroEco.com). 2010.

22. Robert F. Jackson, et al. " Low-Level Laser Therapy as a Non-Invasive Approach for Body Contouring: A Randomized, Controlled Study ". Lasers in Surgery and Medicine 41:799–809. 2009.

23. Antonella Savoia, Simone Landi, Fulvio Vannini, Alfonso Baldi. " Low-Level Laser Therapy and Vibration Therapy for the Treatment of Localized Adiposity and Fibrous Cellulite ". Dermatol Ther (Heidelb). 3(1): 41–52. 2013.

24. Mark S. Nestor, MD, PhD et al. "Body Contouring Using 635-nm Low Level Laser Therapy " .Semin Cutan Med Surg 32:35-40 © Frontline Medical Communication. 2013.

25. McRae E, Boris J. " Independent evaluation of low-level laser therapy at 635 nm for non-invasive body contouring of the waist, hips, and thighs". Lasers Surg Med ;45(1):1–7. 2013.

26. Nestor MS., Zarraga MB. ,Park H. " Effect of 635 nm low-level lasertherapy on upper arm circumference reduction: A double-blind, randomized, sham-controlled trial". J Clin Aesthet Dermatol; 5:42-48. 2012.

27. Kolari, PJ. " Penetration of unfocused laser light into the skin". Archives of Dermatological Research. 277:342–344. 1985. doi: 10.1007/BF00509097.

28. Kolarova, H., Ditrichova, D.,andWagner, J. " Penetration of the laser light into the skin in vitro". Lasers in Surgery and Medicine. 24:231–235. 1999. doi: 10.1002/ (SICI) 1096-9101.

29. Enwemeka, CS. "Attenuation and penetration of visible 632.8 nm and invisible infra-red 904 nm light in soft tissues". Laser Therapy Journal. 13:16. 2003.

30. Smith, Andrew M.; Mancini, Michael C.; Nie, Shuming . "Bioimaging: Second window for in vivo imaging". Nature Nanotechnology 4 (11): 710–711. doi:10.1038/nnano.2009.326. ISSN 1748-3387.

31. Rainer Mittermayr et al. (). " Blue Laser Light Increases Perfusion of a Skin Flap via Release of Nitric Oxide from Hemoglobin". Mol Med.; 13(1-2): 22–29. 2007 Jan-Feb. doi: 10.2119/2006-00035.

32. Gladwin MT, et al. "Role of circulating nitrite and S-nitrosohemoglobin in the regulation of regional blood flow in humans". 2000. Proc Natl Acad Sci U S A.;97:11482–7.

33. Kozlov AV, et al. "Mechanisms of vasodi-latation induced by nitrite instillation in intestinal lumen: possible role of hemoglobin". Antioxid Redox Signal.;7:515–21. 2005.

34. Gladwin MT, Crawford JH, Patel RP.The biochemistry of nitric oxide, nitrite, and hemoglobin: role in blood flow regulation". Free Radic Biol Med.;36:707–17. 2004.

35. Cosby K, et al. Nitrite reduction to nitric oxide by deoxyhemoglobin vasodilates the human circulation. Nat Med. 2003;9:1498–505.

**Table 1: Abdominal circumference measurements before and after LLLT**

|  |  |  |  |
| --- | --- | --- | --- |
| No. of patient | Age | Size before LLLT  (cm) | Size after 12th session of LLLT  (cm) |
| 1 | 40 | U = 80  M = 94  L = 100 | U = 80  M = 87  L = 95 |
| 2 | 50 | U = 77  M = 84  L = 90 | U = 74  M = 79  L = 88 |
| 3 | 38 | U = 103  M =106  L =110 | U = 96  M = 98  L = 104 |
| 4 | 38 | U = 86  M = 95  L = 97 | U = 80  M = 90.5  L = 95 |
| 5 | 62 | U = 91.5  M = 93  L = 95.5 | U = 88  M = 90.5  L = 92 |
| 6 | 32 | U = 86  M = 92  L = 94 | U = 84  M = 88  L = 90 |
| 7 | 56 | U = 92.5  M = 96  L = 98 | U = 89  M = 92  L = 93 |
| 8 | 50 | U = 117  M = 120  L = 127 | U = 114  M =116  L =122.5 |
| 9 | 43 | U = 92  M = 96  L = 103 | U = 89  M = 91  L = 97 |
| 10 | 45 | U = 86  M = 88  L = 93 | U = 82  M = 84  L = 89 |
| 11 | 36 | U = 88  M = 94  L = 95.5 | U = 80  M = 91  L = 95.5 |
| 12 | 62 | U = 91.5  M = 93  L = 95.5 | U = 88  M = 90.5  L = 92 |
| 13 | 38 | U = 80  M = 90.5  L = 95 | U = 76  M = 85  L = 90 |
| 14 | 43 | U = 93  M =102  L = 99 | U = 83  M = 93.5  L = 95 |
| 15 | 30 | U = 98  M = 100  L = 97 | U = 91.5  M = 93  L = 95 |
| 16 | 27 | U = 80  M = 88  L = 92 | U = 78  M = 83  L = 87 |
| 17 | 62 | U = 115  M = 109  L = 110 | U = 108  M = 104  L = 96 |
| 18 | 51 | U = 97  M = 106  L = 115 | U = 93  M = 99.5  L = 108.5 |

Abbreviations: U (upper abdomen), M (middle abdomen), L (lower abdomen)

**Table 2: Results of paired t-test comparing sizes of upper, middle and lower abdomen pre- to post- LLLT.**

|  |  |  |  |
| --- | --- | --- | --- |
| mean±SD | | *T* | *p* |
| Upper abdomen | pre |  | 91.86 ± 11.16 | 7.60 | 0.00 |
| post |  | 87.41 ± 10.52 |
| Middle abdomen | Pre |  | 97.02 ± 8.82 | 12.21 | 0.00 |
| post |  | 91.97 ± 8.49 |
| Lower abdomen | Pre | 100.36 ± 9.45 | | 6.70 | 0.00 |
| post | 95.80 ± 8.52 | |
|  |  |  |

**Table 3: Mean differences comparing the reduction in mean sizes of upper, middle and lower abdomen pre- to post- LLLT.**

|  |  |
| --- | --- |
|  | mean differences from pre to post (cm) |
| Upper abdomen | -4.81±2.31 |
| Middle abdomen | -4.87±4.20 |
| Lower abdomen | -4.12±1.66 |