Safety and efficacy of photobiomodulation therapy for weight loss: a review

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Safety and Efficacy of Photobiomodulation Therapy for Weight loss. A review

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ABSTRACT

Photobiomodulation therapy uses light from a laser and is, therefore, a non-invasive, non-thermal treatment that is effective in reducing chronic pain and inflammation, stimulating wound healing and tissue regeneration. Due to its accessibility and ease of use, it is also being explored as an alternative to lipoplasty for fat removal. This review covers literature focusing on the applications of photobiomodulation therapy, with particular emphasis on the safety and efficacy of this therapy on fat loss. Based on the studies reported, photobiomodulation therapy is a safe technique that showed promising results in reducing the circumference of treated body parts. Also, photobiomodulation therapy is particularly effective when used in combination with exercise and physical therapy. The mechanism of action of how photobiomodulation therapy removes fat from the cells is controversial and requires further investigation. Very little scientific indication endures in support of the claims that infrared light, whether dispensed by laser, lamp, or while in a body wrap, can assist people to lose extra weight or shape their physique. Moreover, additional studies demonstrating the efficacy of photo modulation therapy in larger groups would be helpful in establishing this technique for regular clinical use.

Keywords: Low-level laser therapy (LLLT), fat loss, obesity, lipoplasty, photobiomodulation, weight loss, light emitting diodes (LEDs) therapy.

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1. INTRODUCTION

The obesity rates have more than doubled in adults and children since the 1970's [1], and nearly two-thirds of adult Americans are overweight or obese nowadays [2]. Moreover, obesity was associated with a state of chronic, low-grade inflammation, cancer, increased risk of cardiovascular disease, stroke, type 2 diabetes mellitus, hypertension, and osteoarthritis [1, 3, 4].Due to these health risks and prevalence of obesity, it continues to be a leading cause of preventable deaths. Changes in lifestyle, such as exercising more and consuming fewer calories are the first solutions to combat obesity. In particular, emphasizing portion control, calorie-counting, self-monitoring, and gradual increases in activity, starting with everyday events are the best steps towards a healthier lifestyle[5]. However, localized pockets of stubborn fat sometimes fail to disappear despite diet and exercise, and this can cause stress and lack of self-confidence in individuals. Removing stubborn fat from targeted areas using a series of lipoplasty regimens is a safe and an efficient way of eliminating that fat, and can complement to a medically approved weight loss program [6-8].

The established techniques of lipoplasty including ultrasound and laser methods have provided further advancement in this field. The ultrasound or laser is used to transmit energy to emulsify the fat and make it easier to suction out. However, these techniques are invasive and carry risks of minor and major complications. Common but minor complications are discoloration of the treated skin, infections, numbness, fluid accumulation, and contour irregularities. Serious side effects are reported in 1:5000 cases and include internal puncture, fat embolism, and kidney and heart problems[6-8]. These limitations have led to investigations of non-invasive alternatives for fat reduction. This review will focus on the benefits and safety of photo modulation therapy for weight loss since there are many significant implications for health that many of us are still under-informed about.

1.1. Photobiomodulation therapy

Photobiomodulation therapy is also known as low-level laser therapy (LLLT) and cold laser therapy. It has existed for centuries, but it's only in the last 50 decades that its mechanisms have become partially understood mainly due to the advancement of technology. Most of the original research on photobiomodulation was done with lasers, but now there is a trend in using light emitting diodes (LEDs), which are considered more cost-

effective and no any safety concerns have been reported so far. Therefore, LEDs appears to be a more efficient and economical way to dispense the therapy. This therapy uses red to near-infrared light (with a wavelength range of 630 to 1,000 nm) produced by diode lasers or a combination of helium-neon and gallium-arsenide lasers [9, 10]. Lasers with a spot area ranging from 1 - 10 cm^2 were referred to as low-level lasers[9]. The fluence (energy density) used for this therapy is in the range of 1 and 20 J/cm^2 while the irradiance (power density) can vary widely depending on the actual light source and spot size. Lower irradiance values from 5 - 50 mW/cm^2 are used for stimulation and healing, whereas higher irradiance values are used for nerve inhibition and pain relief [11]. Due to the various methods of photobiomodulation therapy, there is great flexibility in the application that can last from a few seconds to a few minutes, for a few times a week for several weeks. Also, the modality can be either local or distal [9-11].

1.2. Mechanism of photobiomodulation therapy in human cells

Photobiomodulation therapy does not produce heat, sound, or vibration, and instead acts via non-thermal or photochemical reactions in the cell that is also referred to as photobiology or biostimulation[10]. This is comparable to photosynthesis in plants whereby the light is absorbed and exerts a chemical change. In cells, the red visible and near-infrared photons are absorbed by chromophores in the mitochondria, mainly by cytochrome c oxidase (COO), a component of the cellular respiratory chain [10, 11]. This lead to an increase in mitochondrial membrane potential, oxygen consumption, adenosine triphosphate (ATP) production, a transient increase in reactive oxygen species (ROS), and a release of nitric oxide (NO). These signaling molecules activate the transcription factor NF-κB leading to signaling pathways that eventually promote cell survival, cell proliferation, and cell migration[11, 12].Furthermore, the optimal wavelength considered for the stimulation of COO lies in two zones, red at 630 to 660 nm and near-infrared at 810 to 830 nm. Numerous research studies have also failed to identify a difference between red light (660 nm) and near-infrared (810, 830). So, the assumption is that the mid-600s and the entire wavelengths in the low 800s seem to have the same biological effect[13].

What this suggests is that the red light at 630-660 nm will exhibit the same mitochondrial benefits as the near-infrared range of 810 to 830 nm. However, 730 nm does virtually nothing. One emerging theory is that the absorption spectrum of COO has two crests: one in the mid-600s and one at around 800 (figure.1.)[13].

It's important to recognize that photobiomodulation is highly biphasic in dose, meaning the benefit can perish by using too much light. There's a dose range in which it will give you benefit [11,12].

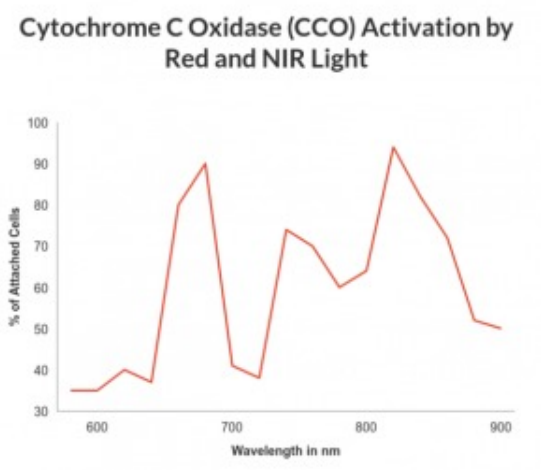


Figure.1. The graph suggests the spikes in CCO activation explicitly in the *mid-600 nm* to *low-to-mid-800 nm* range (red and near infrared)[13].

1.3. Clinical applications of photobiomodulation therapy

While the use of photobiomodulation therapy was met with skepticism in the past, recent studies support its efficacy. This therapy is used widely alongside physical therapy, and chiropractic sessions for chronic pain and chronic joint disorders since previous research suggests that the combined use of two therapies can give expedited results [12-15]. Also, photobiomodulation therapy has shown potential effectiveness in treating soft-tissue injury and wound healing by promoting tissue regeneration and reducing swelling, and inflammation[16, 17]. Preliminary studies have shown that photobiomodulation therapy prevents tissue death, and supports the proliferation and differentiation of cells in a broad range of diseases in the field of neurology, ophthalmology, cardiology, and otolaryngology[10, 12].

Photobiomodulation is more cost-effective than liposplasty and is covered by particular health insurance, unlike lipoplasty that is a cosmetic procedure. However, the optimal wavelength, dose, tissue penetration, the role of coherence and peak power, and repetition rates for the different applications need further investigationsuch that the precise parameters for the clinical use of photobiomodulation can be established [9, 10].

1.4. Photobiomodulation therapy and fat loss

Several studies in healthy men and women have found that photobiomodulation therapy achieved a safe and significant loss in circumference measurements of specifically targeted regions that were measuredover repeated treatments following specific protocols[18, 19]. Furthermore, it was shown that the circumferential loss after photo modulation therapy is not associated with fluid or fat relocation[20]. A physician-led trial using photobiomodulation therapy at 635 nm exhibited promising clinical results for non-invasive body contouring of the waist, hips, and thighs. Participants were treated with 20 minutes of anterior and posterior treatment using a multi-head laser device administered every other day for two weeks. All treated sections showed a statistically significant reduction in size, therefore, validating the clinical efficacy and safety of photobiomodulation therapy[21]. Another research study using I-lipo laser diode system signified waist circumference changes of the abdomen in 20 patients that showed immediate and long-term variations in specific problematic fatty areas utilizing single treatment methods [22].

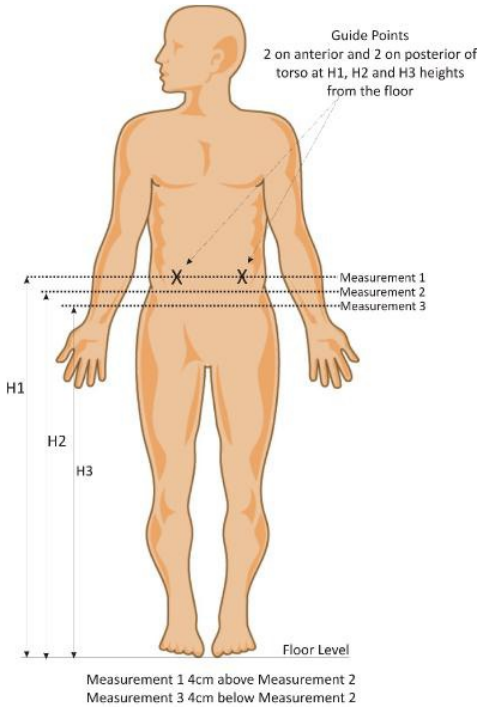
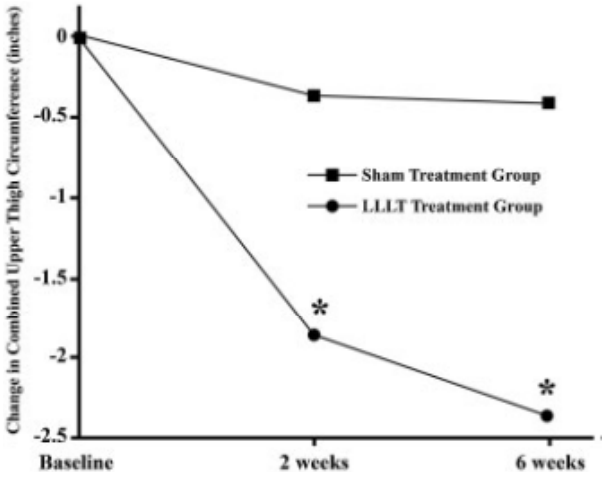


Figure.2. The area of effect where the I-lipo treatment pads are placed on the abdomen gives a working surface coverage area of 109.2cm^2. The pads are each 130mm by 84mm and encompasses nine 40mW, 650nm laser light diodes. From previous studies, it is proven that this particular light of specific wavelength holds sufficient strength for the molecular action at the penetration depth of 10mm into tissue[26-30].

Another research study using I-lipo laser diode system signified abdominal circumferential changes in 20 patients that showed immediate and long-term variations to specific problematic fatty areas (figure.2) utilizing single treatment methods [22].

Further studies in humans have found that strength training associated with photo modulation therapy increases muscle performance decreases exercise-induced oxidative stress, and muscle damage compared to strength training alone. However, photo modulation therapy without exercise tends to increase body weight and fat content [23, 24]. In agreement with this, in studies conducted in rats, the combined use of exercise and photo modulation therapy was found to be effective. The mechanism for loss of fat from the combined treatment was a decrease in adipocyte area due to increased metabolic activity, altered lipid pathways, and increased activity of

the mitochondrial enzyme citrate synthase. This study concluded that combination of exercise and photobiomodulation therapy enhanced the effects of exercise alone [25, 26].



	LLLT-treatment ($N = 23$)	Sham-treatment ($N = 29$)
Change (in.)	Mean (SD)	Mean (SD)
Pre-treatment	47.13 (4.16)	45.59 (4.36)
Post-treatment (Week 2)	45.27 (4.34)*	45.22 (4.35)
Follow-up (Week 6)	44.77 (4.76)*	45.18 (4.44)

*$P < 0.0001$ versus baseline.

Figure 2 and 3. The patients that were treated with photobiomodulation exhibited a significant decrease in combined baseline thigh circumference at the post-treatment (week-2) study endpoint and at follow-up (6-week) evaluation whereas the subjects undergoing sham treatment demonstrated no change. As signified by $P < 0.0001$ versus baseline[29].

In another study where a prototype LLLT device was investigated that utilized six 532 nm green diodes. Each of these diodes had a mean power output of 17 mW whereas the six diodes combined output was 102 mW. Depending on the treatment arm to which each of the patients was randomized to, when the Investigator pushed

the button on the device it turned on the active 17 mW, 532 nM laser or the button which activated a sham 1.25 mW, 532 nM green LED. Figure 3 demonstrated the significant differences observed[29].

1.5. Mechanism of action of photo modulation therapy for fat removal

Limited scientific indication exists to validate the claims that infrared light, whether administered by laser, lamp, or while in a body wrap, can facilitate weight loss in people or shape their physique. Nevertheless, in the year 2010, the Food and Drug Administration (FDA) cleared a laser called Zerona, (manufactured by Erchonia Medical Inc.,) which uses red light therapy to remove "unwanted" fat without invasive techniques. After that, the company performed a clinical trial involving 67 people who either got six laser sessions or six sham treatment sessions over a two week period. The subjects treated by the Zerona laser lost an inch off their waists and hips and lost almost an inch from each thigh. However, two weeks after treatment ended, the fat was starting to return[31-32]. No weight was lost. The mechanism of action of how photobiomodulation therapy removes fat from adipose cells is largely unknown, and available details are hypotheses and speculations. It is expected that the after treatment, the cell will release the fat in vacuoles. However, most studies report no observation of fatty vacuoles when the cells are viewed under a microscope. It is likely that the laser treatment triggers a cellular response that converts triglycerides into fatty acids and glycerol, which can both pass through pores formed in the cell membrane and thus cause shrinkage in adipocytes. However, no data support this explanation, and further studies are required to understand this mechanism thoroughly[12].

2. CONCLUSION

The safety and efficacy of photo modulation therapy in fat removal suggests that it will continue to be used in body contouring procedures. This treatment appeals to a broad range of patients since it is non-invasive and cost-effective. Also, the effectiveness of photo modulation in treating soft-tissue injury wound healing, and chronic pain warrants further study in defining its mechanism of action. Further studies, demonstrating the efficacy of photo modulation therapy, and developing safety protocols would be useful in establishing this technique for regular clinical use.

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