Effect of Red and Infrared LED Light Therapy on Abdominal Fat Reduction

Abstract

Recently, many researches have been conducted on low level light therapy (LLLT) using light from LED or Laser as a noninvasive method for reducing abdominal fat. A total of 40 subjects were randomly divided into 20 test groups and 20 control groups for abdominal fat reduction test. Red and near infrared light (10 mW/cm^2) generated from LEDs was applied on abdominal area to the test group for 30 minutes followed by 30 minutes of aerobic exercise, 3 times a week for 4 weeks. Control group did 30 minutes of aerobic exercise without LLLT application. The waist circumference and body weight were measured for comparison between the test group and control group. The waist circumference of the test group decreased by 0.34±2.71 cm and the waist circumference of the control group increased by 0.36±1.71 cm on average. In addition, the weight of the test group decreased by 0.35±0.93 Kg, and the weight of the control group increased by 0.23±1.28 Kg. Noninvasive LLLT was found effective and safe for abdominal fat reduction without any side effects.

Key words: obesity, abdominal fat, low level light therapy, weight reduction

Introduction

Various diseases are on the rise, following the rapid increase of overweight/obese population (Segula, 2014). It is clear that slowing down the increase of obese population and reducing it will contribute to improving public health. In most cases, people with obesity experience abdominal fat accumulation and reducing abdominal fat is found to be helpful in preventing cardio-cerebrovascular diseases (Karcher, Holzwarth, Mueller, Ludolph, Huber, & et al, 2013). This study examined the effects of low-level laser therapy as a method to reduce abdominal fat. The study focuses on abdominal fat reduction occurred when applying red and near infrared light onto abdominal fat for a certain period of time. It also examined the lipolysis mechanism of red and near infrared light.

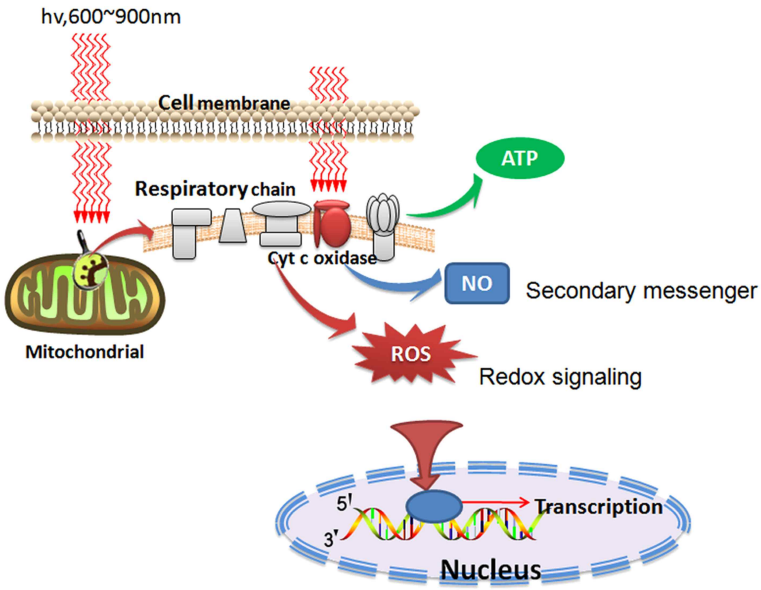
For the past decade, there have been studies on lipolysis, cellulite reduction, and improvement of blood lipid profile through non-invasive methods using low-level red and near infrared light or LED of low-level laser therapy (LLLT). Jackson, Stern, Neira, Clara, & Ortiz-Neira et al(2012), McRae & Boris(2013), Jackson & Maloney(2011), and Avci, Nyame, Gupta, Sadasivam & Hamblin(2013) recently published studies on lypolysis mechanism where red and near infra red light is absorbed in fat cells.

The mechanism of red and near infrared light therapy studied by Huang, Sharma, Carroll & Hamblin(2011) is as follows. Red and near infrared light of 600~900 nm wavelength is penetrated into 4~5 cm deep under the skin and absorbed in cells. Especially, when the light is absorbed in mitochondria, adenosine-tri-phosphate (ATP) is produced at a rapid pace. To be more precise, red

or near infrared light is absorbed in cytochrome c oxidase (COO) that helps the production of ATP and releases free radical at the same time. Signaled by released free radical, production of RNA and DNA is activated in the cells.

According to Huang et al(2011), COO of picture 1 is a high-performance optical absorber. COO produces ATP, aided by oxygen, but nitric oxide (NO) produced by mitochondria prevents COO from absorbing oxygen, thereby making it difficult to produce ATP. When light of 600~900 nm wavelength is applied to COO, COO starts to absorb the light and produce ATP in mitochondria by releasing nitric oxide and absorbing oxygen.

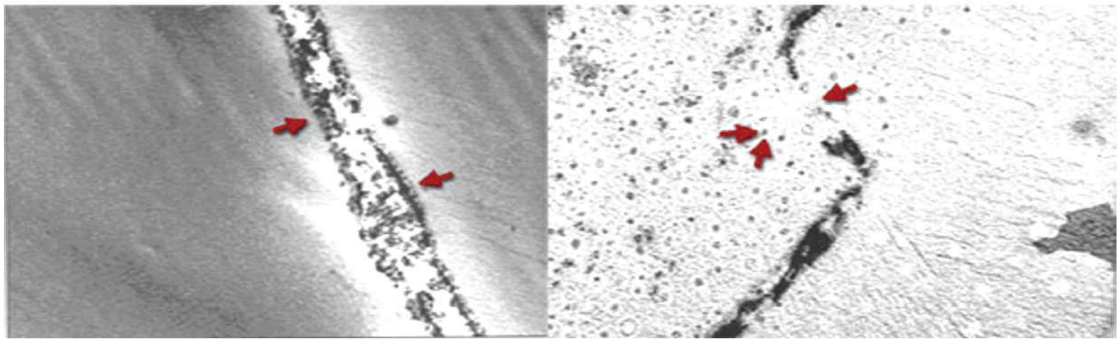
Huang, Sharma, Carroll & Hamblin(2011)



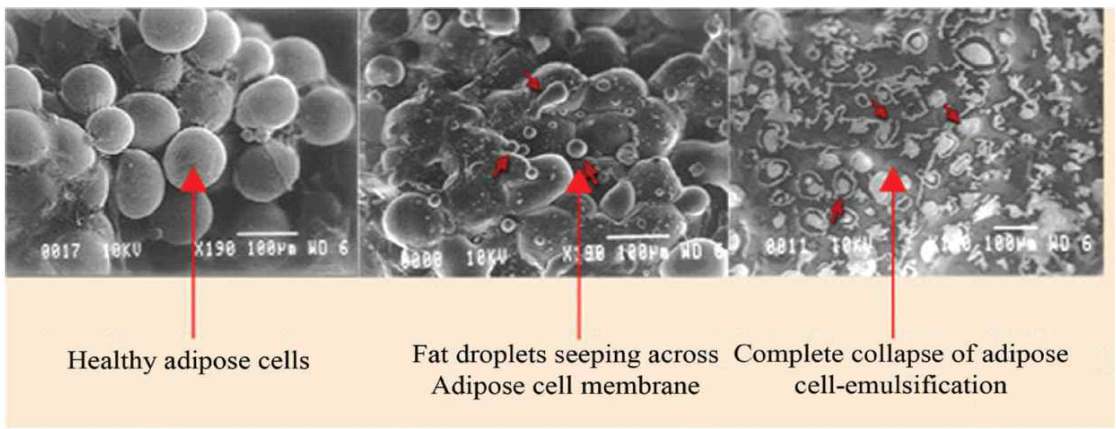
Picture 1. APT production in the cell caused by low-level laser therapy (LLLT) (When light is absorbed in optical absorber in mitochondria, APT production increases and nitic oxide is released.)

When mitochondria in cells absorbs light, it activates ATP production and free radical is formed, followed by RNA and DNA synthesis and cellular multiplication caused by a series of biochemical reaction. According to Hawkins & Abrahamse(2005), Yamaura, Yao, Yaroslavsky, Cohen, Smotrich, & Kochevar(2009), Daniel & Sauder(2010), Arany, Cho, Hunt, Sidhu, Shin et al(2014), Rojas, Bruchey, Gonzalez-Lima(2012) and Gonzalez-Lima, Barksdale, Rojas(2014), there is a lot of remedial value in applying red and near infrared light onto the skin through such mechanism. Especially, clinical papers show that it has been proven effective at pain relief, skin improvement, wound healing, hair regrowth, and improvement in degenerative neuritis, such as Alzheimer's and Parkinson's disease.

Neira, Ramirez, Ortiz, Solarte, and Sequeda et al(2002) published papers saying that fat in body parts, such as abdomen, thighs, arms, and buttocks, can be reduced by applying red and near infrared light to fat cells. According to paper by Avci et al(2013), red and near infrared light is proven effective in cellulite/fat reduction, fat loss in blood vessels, and so on. When red and near infrared light is projected onto fat cells, fat cells absorb light, forming transitory pores on adipose cell membrane which makes it possible for fat cells to make it out of the membrane as in the picture 2. Picture 3 shows transitory pores on adipose cell membrane which has absorbed red and near infrared light.



Picture 2. Scanning electron microscopy (SEM) images of transitory pores formed in cell membrane of adipocytes following LLLT(Neira R, Arroyave J, Ramirez H, Ortiz CL, Solarte E, Sequeda F, Gutierrez MI., 2002).



Picture 3. Scanning electron microscopy (SEM) images of adipocytes following LLLT(Neira R, Arroyave J, Ramirez H, Ortiz CL, Solarte E, Sequeda F, Gutierrez MI., 2002).

Avci et al(2013) presented various experiments to reduce fat as in picture 4 and also showed that non-invasive methods using LLLT have become common nowadays.

Picture 4. Examples of LLLT devices. This figure shows four of the light source devices that either been approved or clinically applied for fat reduction. A: The EML low-level laser for laser assisted liposuction from Erchonia Medical, Inc. B: The Zerona LipoLaser for noninvasive body contouring from Erchonia Medical, Inc. C: The NovoThor LED canopy for weight loss from Thor Photomedicine (Chesham, Bucks, UK). D: The SmoothShapes system for cellulite reduction from Eleme Medical(Huang, Sharma, Carroll & Hamblin, 2011).

Research method

1. Study subject

In this study, healthy adults aged between 18 and 65 were selected as participants. Participation selection criteria and participation exclusion criteria are as follows.

1) Participant selection criteria

- Healthy adults aged between 18 and 65
- Adults who experienced weight change of 3kg within one month
- Those who agree to maintain their usual diet and exercise patterns during the clinical test
- Those who agree to suspend obesity treatment, such as medication and surgery during the clinical test

2) Participation exclusion criteria

- Patients with high blood pressure and diabetes
-Those with medical history of cardio-cerebrovascular diseases
- Those on obesity treatment medicines
- Those who are not qualified for kinesiatrics
- Patients with skin conditions on abdomen
- Those with medical history of light allergies
- Those who were diagnosed with mental diseases
- Pregnant or breast-feeding women
- Those who clinicians think are not qualified for clinical tests

According to these criteria, 13 males and 27 females were selected as participants. Table 1 shows the characteristics of test groups and control groups. Table 2 represents the comparison of height, weight, and BMI between test groups and control groups. Difference of physical traits between the two groups was not significant.

Table 1. Demographic characteristics of test group and control group

Category		Test group n(%)	Control group n(%)
Age	20~29	7(35)	3(15)
	30~39	5(25)	9(45)
	40~49	4(20)	4(20)
	50~59	4(20)	4(20)
	Total	20(100)	20(100)
Gender	Male	7(35)	7(35)
	Female	13(65)	13(65)
	Total	20(100)	20(100)

Table 2. Physical traits of test group and control group

Category	Test group	Control group	P value*
Height(cm)	163.4(6.37)	166.4(11.54)	0.602
Weight(Kg)	71.23(15.38)	73.89(18.48)	0.659
BMI(Kg/m^2)	26.61(3.84)	26.73(4.48)	0.738

* Mann-Whitney U tested

2. Mediation method

40 participants were randomly categorized into test group and control group. Participants in test group wore LumiDiet Belt (Picture 5, Manufactured by Double H) on their abdomen for 30 minutes and then did aerobic exercise (walking) afterwards. They did aerobic exercise 3 times a week (30 minutes for each session) and researchers visited them to verbally check and record their exercise patterns.

Participants in control group did not use the LED device and only did the same amount of aerobic exercise (walking) as the participants in test group.

Picture 5. LumiDiet Belt (Manufactured by Double H)

The clinical test lasted for 4 weeks. In order to measure abdominal fat loss in participants, waist circumference and weight of participants were measured 2 weeks and 4 weeks into the test respectively. Also, pictures of participants' abdomen were taken to compare the difference before and after the test.

Also, on the 2nd and 4th week of the test, verbal surveys were conducted about whether the participants were satisfied and the safety of the device.

All the results were measured as single blind methods.

Table 2 shows the characteristics of the LED device used in the test.

Table 2. Characteristics of LED device used in the test

Item	
Wavelength	640~680 nm + 850 nm
Irradiance per unit area	10 mW/cm^2
Light emitting area	30 cm x 15 cm
Time	30 minutes / session
Dose (Energy transfer per unit area)	18 Joule/cm^2 (Optical power x time)

3. Statistical analysis method

All the results were indicated as mean ± standard deviation. Frequency analysis of measured variables and default statistics were taken into calculation. In order to compare the waist circumference and weight before and after the mediation, Mann-Whitney U test (non-parametric test) was used since the number of research subjects is under 30 for test group and control group respectively. All the tests were analyzed using IBM SPSS statistics 23 program.

This study complies with WMA Helsinki Declaration and has been approved by Institutional Review Board (IRB) of Dankook University Hospital. Based on explanation from researchers, consent was obtained from all study subjects.

Results

Table 4 shows the comparison of waist circumference and weight of 40 clinical test participants before and after the mediation. As in table 4, waist circumference of test group was down by 0.34±2.71 (P>0.05) on average. Waist circumference of control group, on the other hand was up by 0.36±1.71 cm on average. Weight of test group was reduced by 0.35±0.93 kg (P>0.05) on average and weight of control group was up by 0.23± (SD 1.28 kg (P>0.05) on average. In the abdominal obesity treatment that consists of 30 minute exercise (3 times a week) and 4 weeks of light therapy, waist circumference and weight of test group decreased more compared to control group. However, difference before and after the mediation was not statistically significant (P>0.05).

To be more precise, however, waist circumference of 9 out of 20 participants in test group decreased by over 2cm. 4 of them experienced over 3cm or up to 4.7cm decrease in waist circumference. Weight of 9 participants in test group who experienced a decrease in waist circumference of over 2cm was down 0.3 kg on average. Some participants in test group whose waist circumference was down by over 3cm also experienced weight loss of 2.5 kg. Some of the participants in control group experienced a 2cm decrease in waist circumference merely by simple aerobic exercise. Waist circumference of 13 of 20 participants and weight of 15 participants in test group decreased. Some participants in test group did not go with their usual diet and binge ate during the test. As a result, there waist circumference increased 4~5cm, but still there was not any weight change before and after the test. This is because ATP production was activated in cells due to red and near infrared LED light.

Weight/waist circumference reduction was compared between test group and control group in table 5 and 6. Picture 6 shows the changes in waist circumference of participants in test group.

LED therapy to reduce abdominal fat is considered to be safe since no side effect or unexpected abnormal reaction has been reported during the clinical test.

Table 4. Weight/waist circumference changes of test and control group

Category	Test group (N=20) Average (Standard deviation)				Control group(N=20) Average (Standard deviation)			
	Before mediation	4 weeks after	Difference before and after	P value	Before mediation	4 weeks after	Difference before and after	P value
Weight (Kg)	71.23(15.38)	70.98(15.67)	-0.35(0.93)	0.343	73.9(18.48)	74.12(18.34)	0.23(1.27)	0.251
waist circumference (cm)	89.75(10.41)	89.4(10.12)	-0.34(2.71)	0.599	91.9(10.7)	92.2(11.02)	0.36(1.71)	0.616

Table 5. Weight loss of test and control group by grade

Grade	Over 2 Kg	1~1.9 Kg	0.5~1 Kg
Test group (Number of participants)	4	9	12
Control group (Number of participants)	0	3	7

Table 6. Waist circumference reduction of test and control group by grade

Grade	Over 3 cm	2~2.9 cm	0.5~1.9 cm
Test group (Number of participants)	4	9	11
Control group (Number of participants)	0	3	7

a) Before mediation b) 4 weeks after

Picture 6. Change in the shape of the abdomen of test group before and after the mediation

Discussion

The clinical test where red and near infrared LED light of 640~680 nm or 850 nm wavelength was applied to abdomen with aerobic exercise side by side has been proven effective with no side effect or aftereffect. As a result, the method is considered to be non-invasive and safe.

Doing aerobic exercise and red and infrared LED therapy at the same time was effective in reducing abdominal fat. Quantitatively speaking, 65% of participants in test group experienced a decrease in waist circumference and 75% experienced weight loss. For those in test group whose waist circumference reduced over 2cm, 45% of them experienced relatively little weight loss. According to papers by Caruso-Davis, Guillot, Podichetty, Mashtalir, and Dhurandhar et al(2011), red and infrared LED light is absorbed in fat cells and it resolves fat cells, thereby getting rid of fat acid and glycerol from fat cells. Due to this mechanism, LLLT therapy is found to be effective in reducing abdominal fat.

In addition, for some participants in test group with bad constipation, it was reported that their symptoms were relieved during the LED therapy in some cases. In order to prove such effects, more practical clinical trials are necessary in the future. Also, it has been reported that there were improvements in blood circulation and skin elasticity temporarily. According to Avci, Gupta, Sadasivam, Vecchio, and Pam, & Hamblin(2013), this was due to the increase in collagen and fibroblast in the skin as

red and infrared LED light was absorbed in the skin.

There are a few limitations of this study. First, abdominal fat reduction before and after the mediation was not significant. The number of participants was not high enough to acquire statistically meaningful results. Second, 4 weeks of clinical test period was not long enough to prove the effects of LLLT. Third, it was not easy for the participants to maintain their usual diet during the test. Waist circumference and weight can be measured differently depending on what they have eaten on that day.

Despite such limitations, it is considered that aerobic exercise combined with non-invasive LED therapy is an effective obesity treatment method. If the non-invasive LED therapy, which is effective in relieving pain and reducing fat, is combined with aerobic exercise and used as a common obesity treatment method across the country, it will contribute to improving public health and lifestyle habits.

Conclusion

The study comes to this conclusion.

When a single blind study where red and near infrared LED light of 640~680 nm or 850 nm wavelength was applied to 40 subjects (20 subjects in test group, 20 in control group) was conducted, waist circumference and weight of subjects in test group decreased more compared to those in control group who only did aerobic exercise. 9 out of 20 participants (45%) in test group saw their waist circumference decrease by 2 ~ 4.5 cm.

LLLT is considered to be a safe method to reduce abdominal fat as it did not show any side effects or aftereffects during the clinical trial.

LLLT, generally known to be effective in relieving pain, is also proved to be helpful in reducing abdominal fat, according to the test. As a result, it would be effective to use non-invasive LLLD using red and infrared LED light as a obesity treatment method, combined with aerobic exercise.

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