LED or LASER for Low Level Therapy?

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Abstract

The question of lasers' exclusivity, as well as the degree of influence of the special properties of low-intensity laser illumination (LILI), such as coherence, polarity and monochromaticity on the effectiveness of low-level laser therapy (LLLT) continues to cause arguments.

The study analyzes publications from 1973 to 2016, in which laser and conventional light sources are compared, and the following conclusions are drawn. Firstly, there are a lot of publications with incorrect comparisons or unfounded statements. Secondly, other sources of light are often referred to as LILI without any proof. Thirdly, all studies, in which the comparison is carried out correctly and close parameters of the impact and the model are used, have a firm conclusion that laser light is much more effective. Finally, it is clearly identified that the most important parameter that determines the efficiency of lasers is monochromaticity, i.e., a much narrower spectral width than for all other light sources.

Only laser light sources can be used for LLLT!

Keywords: low level laser therapy, monochromaticity, medicine, veterinary

Low level laser therapy – a method of treatment which appeared in the late 1960's in countries in Eastern Europe, followed by significant development in the USSR (Moskvin S.V., 1997), and is now continuing to gain recognition around the world. The results of numerous studies of the laws of the biomodulating action (BA) of low-intensity laser illumination (LILI), carried out on animals, and their treatment regimens formed the basis of the method, widely used both in veterinary medicine and other medical fields: urology, neurology, dentistry, pediatrics, otorhinolaryngology, gynecology, etc. (Ivanchenko L.P. Et al., 2009; Kochetkov A.V. et al., 2012; Moskvin S.V., Amirkhanyan A.N., 2011; Moskvin S.V. et al., 2010; Mufaged M.L. et al., 2007; Nasedkin A.N., Moskvin S.V., 2011; Fedorova T.A. et al., 2009).

The question posed in the title of the article is completely rhetorical: is it permissible to utilise non-laser light sources for *LASER* therapy? Nevertheless, this problem exists, and it is becoming more and more relevant every day.

The fact is, the term Low Level Laser Therapy (LLLT) originally came about to be specifically about lasers (Al-Watban F.A.H., Zhang X.-Y., 1995), but more and more often, the abbreviation LLLT was read as "low level laser (light) therapy" (de Brito Vieira W.H. et al., 2014; Thunshelle C., Hamblin M.R., 2016), or the word "laser" was replaced by "light" as a synonym (Zigmond E. et al., 2014), unequivocally declaring the alleged absence of differences (Enwemeka C.S., 2006) and guided by good intentions, so as not to "get confused" (Enwemeka C.S., 2005 (1)).

The motivation for these actions is incredibly strange: "Both laser and light are photons, light is light, so there is no difference" (Enwemeka C.S., 2005, 2006). While it's not clear whether the statement was made due to ignorance of factual material or as a deliberate assumption, the statement still stands. Let's try to figure out why this is a dangerous assumption, and why you cannot use a jackhammer instead of a scalpel for a surgical operation, despite both tools being made of iron.

The main property of laser light is its monochromaticity, there is only one wavelength in the spectrum, and this is what determines its higher efficiency, which is unachievable for other light sources. Let us first consider this issue from a historical point of view, the evolution of light - or phototherapy.

Therapeutic properties of "concentrated" light, i.e. lamps (e.g. UV, blue or red) isolated by a narrow part of the light filter from the total spectral illumination range, were known already in the nineteenth century. This discovery formed the basis for a new field of medicine – light- or phototherapy, and in 1903, N.R. Finsen was awarded the Nobel Prize "in recognition of his contribution to the treatment of diseases, especially lupus vulgaris, with concentrated light illumination, whereby he opened a new avenue for medical science". All researchers of that time were convinced that to improve the effectiveness of phototherapy it was necessary to meet the following conditions: *decrease the width of the spectral range* to the limit and set the *optimal* light capacity, contact area and exposure. (Finsen N.R., 1896; 1899, 1901; Bang S., 1904; Bie V., 1903; 1906; Rieder H., 1902; 1911).

Laser light is not only monochromatic, but it is also much easier to set and control its energy, allocate it over a surface and deliver it to the required location without loss, which cannot be said about an average lamp with a filter. Lasers appear to be not only convenient but also a fundamentally more effective instrument to achieve a therapeutic effect than other light sources, which determined the emergence of a qualitatively new direction of phototherapy – low level laser therapy (Moskvin S.V., 1997).

Before you begin to analyse various studies regarding this, there needs to be an understanding of technical terms and issues. In particular, the comparison of the spectrum of different light sources and their modes of operation. We also must draw attention to another important detail - in many scientific works, the abstract term "coherence" is used without focusing on two separate components of this term: *spatial* and *temporal*, which are fundamentally different in terms of their physical meaning and their very core, and therefore, must be treated independently. In short, spatial coherence is the distance at which the light flux remains coherent, and does not affect the efficiency of biomodulation, only because it disappears almost immediately in the upper layers of the skin. But here, the temporal coherence, or the degree of monochromaticity is retained until it is completely absorbed in the biological tissue.

We will not be discussing the role of polarisation in BA in detail for now as that is the subject of a separate study, however, it is worth mentioning that for laser sources, its contribution to the overall result is small, but when using broad spectrum light sources, it is extremely important. Unpolarised light is often completely useless from a medical point of view.

When analysing various studies, my own scientific research, experience and basic knowledge of the fundamentals of biophysics, it makes it easy for me to state that it is impossible to consider the question of the significance of specific properties of laser light from the point of view of extremes, if whether there is absolute "coherence". It is necessary to estimate the width of the spectral line with specific numbers for the correct interpretation of the experimental data, to allow the change from qualitative estimates to quantitative ones.

Modern techniques to vary the width of the spectral line with the control of the exact value of this index make it possible to successfully carry out experimental work in this field. Oftentimes, we can compare the BA of laser (or LED) with thermal or gas-discharge light sources (lamps). The latter, with the help of various monochromators (interference filters, diffraction gratings, etc.), have a relatively narrow spectral line of a width up to 8-14nm that is cut out at the wavelength of the laser in the comparison study. The incoherent illumination of all light sources, other than lasers, is called "monochromatic incoherency", "narrow-band light", "incoherent narrow-band", etc. (Karu T.Y. et al., 1982 (1), 1983; Lobko V.V. et al., 1985; Lubart R. et al., 1992).

Figure 1 shows the comparison of the spectra of a lamp with a special light filter, a light-emitting diode and a laser diode. The first graph is drawn from the work in which the authors measured the transmission spectrum of devices from the museum N.R. Finsen (Møller K.I. et al., 2005), the typical spectra of LED's and laser diodes are given from the catalogues of NICHIA and OSRAM, respectively. The LED has a spectrum narrower than the old lamps (and they are more convenient to use), but it is in no way comparable to the width of the spectral line of laser diodes, as it is practically one wavelength!

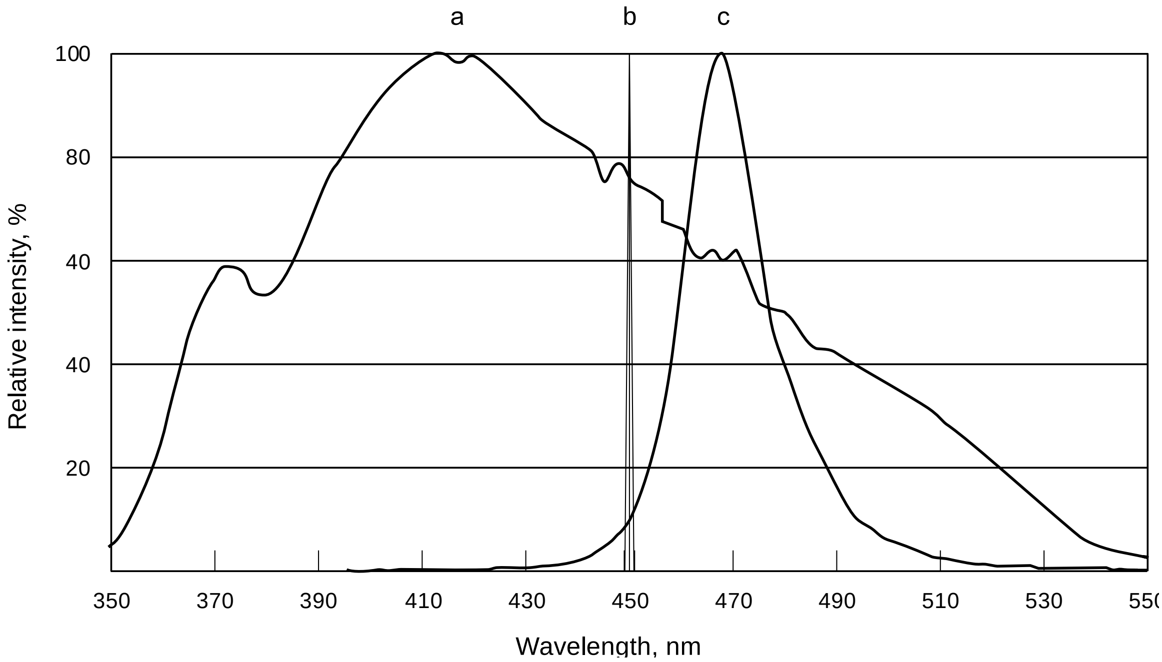


Fig. 1. Spectra of a Finsen lamp with a special light filter (a), a PL 450B OSRAM (b) laser diode and an NHSB046AT NICHIA light emitting diode (c)

In connection with this comparison, it is worth mentioning that this is fraud, and is simply said to be "legitimate" when it is convenient for the "treatment", a conventional LED lamp is offered without any filter, and it is precisely as its advantage is claimed (http://www.bioptron.com/How -it-Works / Bioptron-Light-Therapy.aspx):
"A broad range of wavelengths from 480 to 3400nm, containing the color range of visible light wavelengths plus a part of the infrared spectrum. Different light wavelengths penetrate the skin at different depths, activating cells, accelerating local blood circulation and stimulating the whole body's regenerative processes". We can only sympathize with those who have already spent a lot of money on absolutely useless "treatments", and advise those wishing to "be treated" in this way, to buy an ordinary table lamp at any hardware store that will cost hundreds of dollars (!) less.

Another difference between laser diodes and LEDs is in their operating modes, of which there are two main ones - continuous and pulsed. Low-intensity laser illumination (LLLI) in continuous mode is more often used for laser acupuncture (wavelength 635nm, power 2-3mW) and intravenous laser blood illumination (ILBI) (wavelength 365, 405, 445, 525 and 635nm, power from 2 to 20mW), and (but less often) for local exposure, when the lesion is localized close to the surface (different wavelengths, power from 10 to 200mW). Sometimes, incoherent LED light is also used in these techniques, albeit with less efficiency.

Continuous illumination can be modulated, i.e., change its intensity during the procedure, as is done with a signal lamp on ships, switching on/off which transmits messages with Morse code. Both laser and conventional light may be modulated, but modulation is used quite rarely and it is often confused with pulsed mode. If there are such things such as pulsed laser diodes, then such LEDs do not exist.

Let us make it clear. Pulsed lasers do not operate in a continuous mode in practice, but they generate impulses with high pulse power (for therapy use, the power is usually used is from 10W to 100W) at a constant duration (100-200ns). It is always necessary to indicate the repetition frequency of the pulses in the technique for these lasers, since the average power is proportional to the following formulas:

$P_{average} = P_{pulse} \times F \times \tau$, where:
$P_{average}$ - average power,
P_{pulse} - impulse (peak) power,
F is the repetition rate of impulses,
τ - duration of pulses (constant value).

When using the formula, a pulsed power of 10-15W and a frequency of 80-150Hz (such parameters are most often used for the infrared (904nm LLLT), the average power will be approximately 0.1mW, which is 100-1000 times less than the power used for continuous light sources. Therefore, laser light in the pulsed mode is used 100-1000 times more efficiently than continuous mode to procure similar reactions of the biological systems. But impulse LED's do not exist, therefore, it is impossible to achieve such efficiency.
Therefore, only LLLT in the pulsed mode allows the implementation of techniques, such as:

- non-invasive laser blood illumination (NILBI);
- affect the deep tissues and organs,
- affect to immunocompetent organs;
- affect the nerve nodes;
- transcranial technique.

Some may argue that NILBI can also be achieved with the help of continuous LLLT (i.e., potentially can be achieved with LED light). For example, the "Chinese" version is an intranasal technique in which the localization is motivated by a close arrangement to the surface of the capillaries, even though it is the mediated role of the nervous system (Liu TCY Et al., 2010, 2012). Many times, it has been discussed that illumination of the peripheral vessels cannot be called NILBI, as it is important to only act upon on large blood vessels (veins and arteries) to obtain an adequate response.

In addition, with the endonasal technique, the effect is performed on the hypersensitive neuroendocrine reflex zone and is accompanied by the reflexive excitation of the hypothalamic formations controlling the secretion of biologically active substances participating in various processes: stimulation of uterine contraction, regulation of the circulatory and reproductive systems, control of the production of various hormones (follicle stimulating hormone, estrogens), etc. (Serov V.N. et al., 1988, 2007; Ramdoyal S., 1990). Therefore, this effect is exclusively mediated, and is not associated with direct exposure to the blood. Otherwise all illumination would be conducted on the lips, since there is simply no better access to the capillaries than there (and no effect either). But the endonasal technique is extremely dangerous with unpredictable consequences, especially for women and their fertility. Unfortunately, this technique has been widespread in China.

Arguments upon the topic of "lasers or LED’s" have long since gone from being purely scientific discussion, to discussions from an economic perspective. The fact is that numerous creators of "pseudo-lasers" are actively (and quite successfully) trying to sell such products under the brand name of "LLLT", justifying their actions precisely by the lack of specificity of laser light and its efficiency. For example, a review by H. Chung et al. (2012) which included very few and unreliable studies which did not show the effects from laser exposure, generally stated that the prospects for the development of *laser* therapy are associated with the use of LED’s. It is quite obvious that such statements are simply made by people who aim to make their devices look better by trying to belittle laser therapy. If their devices are so effective, then why do they use the term “laser” and use other brands? Why don’t they do some research, show the results, call it something suitable, such as "LED therapy", or, as suggested by R.C.A. Pizzo et al. (2010[1]), "LEDytherapy", and develop it in a whole new direction. But why don’t they do this? The answer to this question is obvious: there is a lack of effects produced from incoherent light sources, the insignificance of the effects, and most people understand that the term "LED therapy" will quickly become useless if it is not "covered" with highly effective laser therapy, while at the same time discrediting the term laser therapy.

It is clear to everyone, that an objective conclusion can only be made when only one parameter - the width of the spectral line of the light sources - is different in comparative studies. All other variables must be kept constant. Therefore, when analysing scientific sources, it is necessary to carefully evaluate the correctness of the comparison, paying special attention to the identity and optimality of all parameters of the techniques.

For example, it is completely unclear on what basis G.A. Zalesskaya and his co-workers. (2013) drew conclusions "…upon the absence of significant differences in the mechanisms of the effects of laser and non-laser illumination," when only the shift of the haemoglobin dissociation curve was observed after Ultraviolet Blood Illumination (UVBI) (254nm, 20 minutes, extracorporeally) and NILBI (670nm, 15 minutes, per cubital vein). At the same time, the difference in methods – in particular, the wavelength - is not considered. It should also be mentioned that the patients underwent complex treatment, because of which these revealed changes could also occur. It would be the same as comparing the effectiveness of LILI with the effectiveness of morning exercises – completely different methods of treatment, but may yield the same result.

Let's give another, even more vivid example of incorrect conclusions, in which the BA of laser light and LED’s with different wavelengths were compared on the model of stimulating the proliferation of fibroblasts *in vitro*. Statistical analysis - according to the authors - showed a higher proliferation rate in all groups compared to the control group, but the green LED light (570nm) significantly stimulated cell division more than the red (660nm) and the infrared (950nm), suggesting that all LED’s are more effective than laser light (Vinck E.M. et al., 2003). But how can a conclusion like this be drawn when the energy parameters (power, area, power density (PD), energy density (ED) and exposure) differ for LLLT and incoherent light by tens of times! It is obvious that only three groups with LED’s can be compared more or less correctly in this study, and even with reservations (Table 1).

Table 1
Parameters of the light sources used in the E.M. Vinck et al. (2003)

<table>
<tr><th>Wavelength, nm</th><th>Power, mW</th><th>Area, см^2</th><th>PD, mW/см^2</th><th>Exposure, secs</th><th>ED, J/см^2</th></tr>
<tr><td>830 (laser)</td><td>40</td><td>0.196</td><td>204</td><td>5</td><td>1</td></tr>
<tr><td>570 (LED)</td><td>10</td><td rowspan="3">18</td><td>0.56</td><td>180</td><td>0.1</td></tr>
<tr><td>660 (LED)</td><td>160</td><td>8.89</td><td>60</td><td>0.53</td></tr>
<tr><td>950 (LED)</td><td>80</td><td>4.44</td><td>120</td><td>0.53</td></tr>
</table>

De Sousa A.P.C. et al. (2013) concluded that the light of both LED’s and laser diodes approximately equally stimulate angiogenesis in animals (Wistar rats), however, for LLLT, the least effective or least optimal wavelengths, 660nm and 790nm were chosen, or the concentration of light energy in a point, rather than its distribution over the area, which led to a completely unacceptable PD with unreasonably high power. The exposure of 168 seconds and 200 seconds, to put it lightly, is not optimal. A similar error was made in an earlier paper (Corazza A.V. Et al., 2007).

There are many studies like these that can be given as an example in this article, and it is likely that someone may soon begin comparing the effectiveness of LED with a laser device which isn’t even switched on, and then claim that the latter is completely ineffective!

In a study by T.N. Demidova-Rice et al. (2007) there is another problem. There here was no difference found in the wound healing effect (side excision wounds of 10×13mm in BALB/c and SKH1 mice), both from incoherent lamp light (635 ± 15nm) and HNL (633nm, 2J/cm2) (Demidova-Rice TN Et al., 2007), and the reason for this being that an incorrect time of 30 minutes was used for the study. With such exposure, which exceeds the maximum permissible level several times, the effect should be absent regardless of the light source, so it is impossible to draw general conclusions. Specialists also know that exposure to illumination of one zone should in no circumstances exceed 300 seconds (5 minutes) (Laser therapy ..., 2015).

Many researchers have tested the biostimulating properties of LLLT and light from incoherent sources (depolarized with a wide spectrum) in different models, but the results vary considerably. A lot, obviously, depends on the experimental model, however, the general nature of the conclusions drawn speaks in favour of greater monochromaticity efficiency - the narrower the spectrum, the higher the effect at a lower power density.

One of the first comparisons like this was conducted by D. Haina et al. (1973). Effects on experimental wounds (249 Wistar rats) with HNL light (group I) and incoherent light with the same wavelength (group 2). In the first group, the growth of the granulation tissue increased by 13% with ED 0.5J/cm2 and by 22% with a more optimal EP of 1.5J/cm2, while in the second group, the increase did not exceed 10%.

Our comparative evaluation of the quantitative results from several dozen studies has shown that the therapeutic effect causes light with a spectral bandwidth less than $\Delta\lambda \approx$ 15-20nm, and with a spectral band width of less than 3-5nm, further narrowing of the spectrum does not lead to an increase in efficiency (Moskvin S.V., 2003), which was confirmed by the data of other authors (Budagovskii A.V., 2005). As an example, let us cite several studies with known widths of the spectral line of light sources, which confirm our findings.

Experiments by V.A. Dubrovsky et al. (1982) showed that the light absorption coefficient of hemolysate, oxyhemoglobin, and catalase does not depend on the spatial coherence and degree of polarization of light. The contribution of temporal coherence (monochromaticity) is much more significant. The illumination of the investigated molecules directly and with the laser light and with the light of the incandescent lamp through light filters showed that the illumination from the helium-neon laser (HNL) is absorbed several times (depending on the concentration of the object under study) more actively than incoherent light with a larger spectral width. This advantage of LILI is attributed exclusively to the fact that the absorption coefficient of incoherent light, averaged over the width of the emission spectrum of an incandescent lamp ($\Delta\lambda \approx 10$ nm), is lower than the corresponding coefficient for a laser beam, determined essentially for only one wavelength.

V.U. Plavsky and N.V. Barulin (2009) clearly demonstrated the dependence of the effect on the width of the spectral line with the effect on fertilized eggs of sturgeon. By the way, the third variant, a so-called "white" LED, had wavelengths in another area of the spectrum, specifically, the blue and green (Fig. 2).

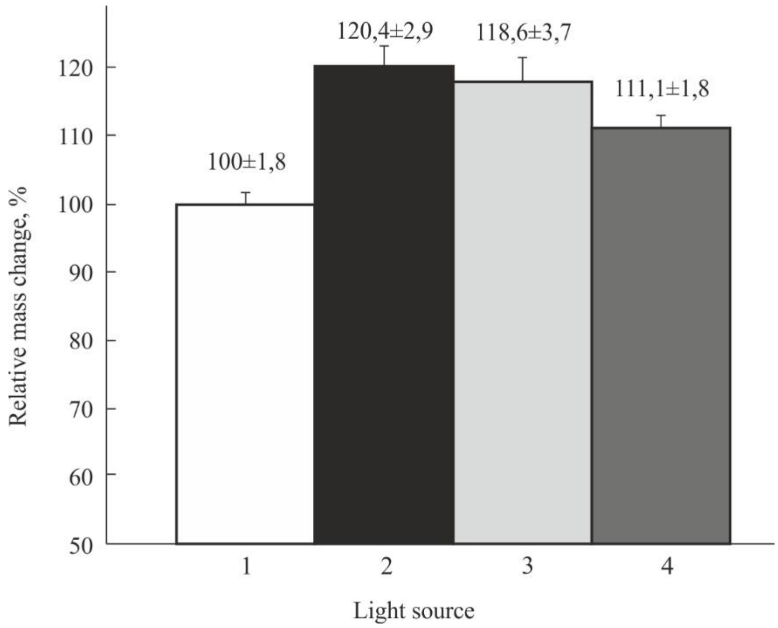
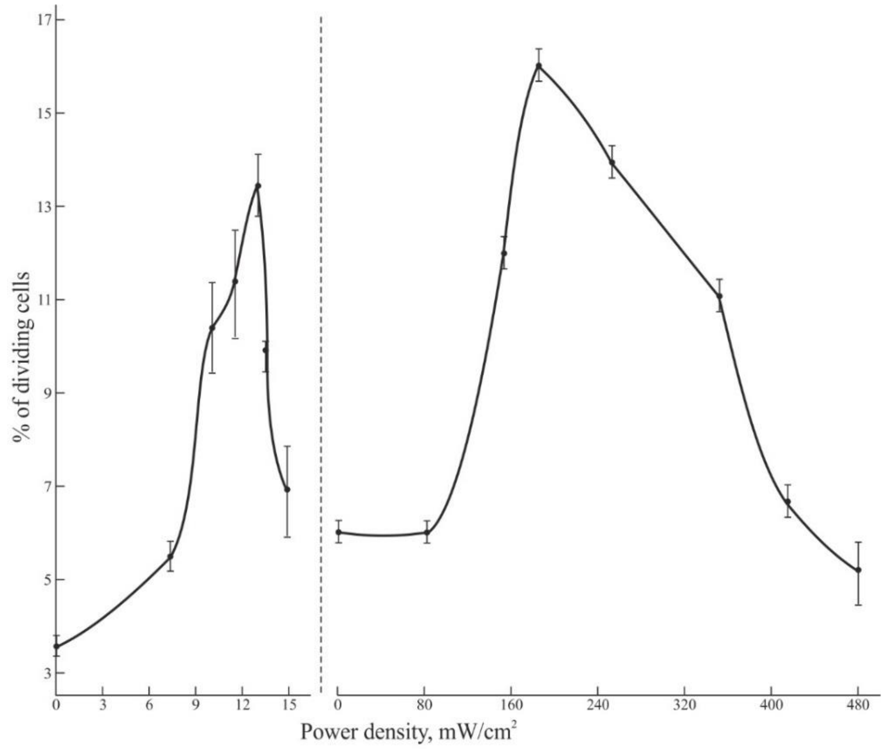


Fig. 2. Influence of the degree of the monochromaticity of the polarized light (power density 2.9mW/cm2, exposure 60 seconds), when exposed to fertilized eggs, on the mass of 50-day-old juveniles of sturgeon: 1-control; 2 - GNL (λmax = 633nm, $\Delta\lambda$ = 0.02nm); 3 - LED (λmax = 631nm, $\Delta\lambda$ = 15nm); 4 - "white" LED (λmax1 = 453nm, $\Delta\lambda \approx$ 20nm, λmax2 = 567nm, $\Delta\lambda \approx$ 130nm) (Plavsky V.Yu., Barulin NV, 2009).

Usually, research compares the effect of coherent (lasers) and incoherent light sources. The work of R. Lubart et al. (1993) is one of the few that did not include lasers, studied the photobiological effect of light only on LED's with a wavelength of 540nm ($\Delta\lambda \approx$ 5nm) and a lamp with a filter in the spectral range of 600-900nm ($\Delta\lambda \approx$ 300nm), allowing you to draw interesting conclusions. Firstly, we find confirmation of the significance of such a relative index as the spectral power density. In Fig. 3, the energy parameters optimal for stimulating cell division (human skin fibroblasts) for two different light sources, depend on the power density (upper graphs) and the energy density (lower graphs) with the same exposure (300 seconds) (Lubart R. et al., 1993). The effect, albeit insignificant, was observed in both cases, however, the wider the spectrum, the greater (and more significant!) the values of power density and energy are needed to achieve the result. Such conclusion fits perfectly into the model of the thermodynamic triggering of Ca2 + -dependent processes that we proposed: the narrower the spectrum, the more significant the temperature gradient arising from the absorption of photon energy (Moskvin S.V., 2008). In this work, a lot is said about the role of Ca2 + in the response to illumination of a living cell.



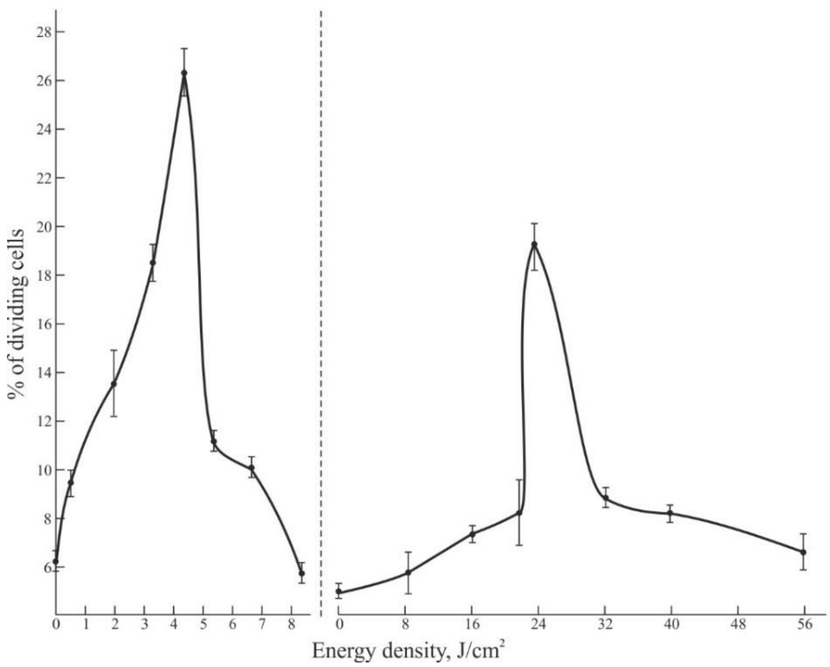


Fig. 3. Stimulation of cell division as a function of power density (top) and ED (bottom) for LED (left), $\lambda = 540 \pm 5$nm, and lamp with filter (right), $\lambda = 600$-900nm (Lubart R. et al., 1993).

In experiments with cell culture (mitotic activity of Staphylococcus aureus), almost no differences were found in the effects of LLLI of the single-mode lasers with a spectral line width of less than 0.1nm and multimode diode lasers with $\Delta\lambda \approx 4$nm with a single wavelength

(1300nm) (Koltsov Yu.V., Korolev VN, 1998). In this range of values of this index, there are no changes with a decrease in the width of the spectrum, therefore, one should not strive to use single-mode, let alone single-frequency lasers in laser therapy.

T.Y. Caru et al. (1982) obtained for HeLa cell culture in vitro differences in the growth of permeability of cell membranes for H3-thymidine by 20%, and an increase in DNA synthesis by 15% after exposure to GNP illumination and filtered incoherent light from a lamp with a close wavelength and spectral band width ≈ 14nm. Laser light was, of course, much more effective. In the opinion of the authors, the absence of a more pronounced dependence of the effect on the width of the spectral line is explained by the difference in the rates of creation and relaxation of coherence. The rate of excitation of the molecules ("creation of coherence") is 0.003-0.03s^{-1} at a power density of the LLLT being in the range of 1-10mW cm2, while the rate of loss of coherence of excitation due to the dephasing of the wave functions of the excited states of molecules in the same conditions were approximately 10^{11}–$10^{12}s^{-1}$. That is, the significance of the spectral line width in the achieved effect is directly related to the effective absorption cross section of the molecule.

M. Boulton and J. Marshall (1986), observing an increase in the proliferation of fibroblasts in vitro alongside a 15-minute previous illumination using HNL (633nm) and a halogen lamp with a filter (640nm, $\Delta\lambda \approx 9$nm), showing that if LILI significantly speeds up the process (by 20-40%), then the lamp's light has no effect. However, the parameters of the method were very strange, the exposure was much larger than the optimal values, the power density was only 0.1mW cm2, and the laser was being operated in modulation mode (F = 100Hz, $\tau \approx 3$ms, Q = 3), which does not ensure absolute correctness for a comparison, as the lamp was working continuously.

S. Rochkind et al. (1989) studied the therapeutic efficacy of light at five different wavelengths when exposed to peripheral nerves. The illumination of the HNL (633nm) resulted in an increase in the functional activity of the damaged nerve, while incoherent light (660nm) proved to be much less effective, and the effect of infrared LLLT (830nm) and incoherent light (880nm and 950nm) did not cause any effect.

HNL stimulates the activity of lymphocytes and macrophages in vitro, causes an increase in phagocytic activity, the release of immunoglobulins. A similar result is not observed when exposed to ordinary monochromatic light with the same wavelength (at maximum) and at the same energy density (Berki T. et al., 1985, 1988).

Reliably better (by 45%) than in the control group and with the use of LED’s, there was wound healing in the group of animals (Wistar rats) when they were exposed to the laser diode illumination (wavelength 830-840nm, ED was chosen to be optimal, equal to 1J/cm2), that is, the full inefficiency of LED’s is demonstrated on this model (Ohshiro T., Calderhead RG, 1988).

If laser light (HNL) significantly increases the viability of sea urchins, sea cucumbers and bivalve mollusks, then the LED (850nm) has no influence (Chudnovsky VM, 2002).

J. Kubota, T. Ohshiro (1989), on the model of artificial injury (Wistar rats) showed that after illumination with a diode laser (830nm), the bruised tissues had better perfusion, more capillaries, and significantly increased blood flow velocity. These differences in the groups of the rats that were LED illuminated (840nm) and in the control group were not observed.

Pöntinen (1995) measured by the method of laser Doppler flowmetry of the state of capillary blood flow to the scalp of healthy men 30 minutes after the effect of LLLT (670nm, ED 0.12-0.36J/cm^2 per four zones) and LED (635nm, EP 0.68-1.36 J/ cm^2) showed that laser light leads to an increase in local blood flow, whereas the illumination from LED’s causes a reverse effect.

E.L. Laakso et al. (1994) examined 56 patients with chronic pain syndromes according to the double-blind control method, a significant increase in adrenocorticotropic hormone (ACTH) and β-endorphin levels was observed in the two groups of laser therapy (820nm wavelength, 25mW power, and 670nm wavelength, Power 10mW). The effect was not observed in the group of patients who were illuminated with LEDs (wavelength 660nm, spectral width 30nm, power 9.5mW).

Phototherapy with a lamp for men with the syndrome of delayed muscle pain (660-950nm, 31.7J/cm^2, exposure 12 minutes, modulated, frequencies 2.5, 5 and 20Hz) was completely ineffective (Craig J.A. Et al., 1996). Here, again, we must make a reservation regarding the non-optimal exposure.

I. Bihari and A. Mester (1989) conducted a comparative evaluation of treatment (with a double-blind control) of three groups of patients with long-healing ulcers of the lower limbs. In the first group, only HNL was used for illumination, in the second group - HNL and diode laser, and in the third group - incoherent and unpolarised light. Patients in groups one and two were cured (in group two the results were somewhat better than in the first group), in the third group no significant effects were observed.

Similar regularities were also revealed in experiments with plant cells, if low-intensity laser illumination of the HNL (633nm) exerts a significant stimulating effect on morphogenetic processes (the formation of zones of secondary differentiation, rhizogenesis, regeneration) in the culture of wheat tissue, then incoherent light with the same wavelength does not cause a cell reaction (Dudareva LV, 2004).

Let's pay attention to one more circumstance. It is often enough that LEDs serve as light sources that simulate a laser in studies with a placebo control. For example, it is shown that incoherent light does not exert any influence on patients with heroin addictions with a pronounced effect after laser exposure (Nasedkin A.A., 2004; Nasedkin A.A., Moskvin S.V, 2004).

Thus, NON-laser light sources (lamps with or without filters, LED's with or without a polarizer, etc.) cannot be used in laser therapy because of their minimal efficiency. Obviously, LED's have their niche in a vast field of light therapy, for example, they are very successfully used in photodynamic therapy, UV LED's have a good bactericidal effect, but to expect clinical effects similar to those obtained precisely in laser therapy using laser light (LLLT) from them may be a waste of time.

Laser therapy – as the name suggests, should only be conducted with lasers!

LLLT – Low level laser therapy
LILI/LLLI – low intensity/level laser illumination
LED – Light emitting diode
BA – Biomodulating Action
HNL – Helio-Neon Laser
PD – Power Density
ED – Energy Density

Translated by Svetlana Kisseleva