Moskvin S. V. Low-level laser therapy and light energy // Photobiomodulation, Photomedicine, and Laser Surgery. – 2019, 37(5): 267–268. doi:10.1089/photob.2019.4622

Final publication is available from Mary Ann Liebert, Inc.: http://dx.doi.org/10.1089/photob.2019.4622

Low-Level Laser Therapy and Light Energy

Sergey V. Moskvin, DBiolSci, PhDTechSci

Numerous publications have often mentioned quantities such as ''energy'' or ''energy density'' as basic and as the only parameter describing the low-intensity laser illumination (LILI) technique, both in model experiments and in clinical trials.

To tell it straight, this is completely unacceptable since these parameters are in no way connected to the laser illumination methodology; that is, they do not describe it sufficiently to explain the idea of reproducibility. Not a single expert, after just having read this description (mentioning energy as the only parameter), will ever be able to reproduce the exposure technique.

We will try to gain insight into this statement, which turns out to be controversial, and this fact makes us wonder a lot. In addition, the *majority* of ''specialists'' who give negative reviews to our publications on the grounds that ''energy or dose is not indicated'' strongly disagree with our position.

One can cite a study allegedly ''determining optimal ranges for laser parameters'' as an illustrative example of this delusion;[1] however, these authors operate solely using the terms mentioned earlier, as well as a certain ''dose.'' There is not the slightest use in such ''optimization''; it is like looking for a link between the weight (size or color) of a laser device and the efficiency of its use.

Moreover, later someone who is referring to the magical term ''meta-analysis'' (it is precisely this that the aforementioned article makes pretense to) as a synonym for ''ultimate truth'' will choose the supposedly optimal energy density while ignoring other parameters, and then he or she will not receive the expected result and say, ''It is *proved* that low-level laser therapy is not effective.'' It will even be worse if a patient is injured—and this is easier to do than someone thinks.

Thus, let us try to look into this matter.

As a reminder, *energy* (J) is the result of *calculations*; power (W) must be multiplied by time (sec), and *energy density* (J/cm^2) is obtained by dividing by the value of the light spot area (cm^2).

The purpose of these senseless arithmetic operations has always been a riddle for me personally. The only argument that I have heard many times from the opponents is ''we are used to doing this; we were trained that way.''

In my opinion, it is time to give up bad habits and start working properly. After all, one can divide the wavelength of laser light (m) by the exposure (sec), and name the resulting value having the dimension of velocity (m/sec), for example, a ''rose'' (by analogy with the term ''dose''), and try to find the ''optimal'' value of this parameter. What will it give? Nothing, absolutely nothing, as well as ''dose'' and ''energy''!

We recommend getting acquainted with the classic studies of the founders of phototherapy (Finsen, 1899)[2], who had never mentioned joules, but always focused attention on the spectrum, power, exposure, light spot size, and exposure localization in their techniques. N.R. Finsen was awarded the Nobel Prize precisely because he proved the need for ''concentration'' of light for effective treatment, that is, the selection of a narrow part of the spectrum using a light filter. All his opinion allies and followers were also convinced that the narrower the spectrum, the greater the effect. But now the description of the technique is often as follows: ''any light source+joules calculator.'' However, I think that everyone should begin work with getting to know the studies of Finsen and his followers.

Let us consider, for clarity, the examples of possible optional methods with the same energy and give some recommendations.

With the following *optimal* parameters of the methodology, which must always be set separately (exactly each parameter), and local illumination of a group of cells or an organ, we shall obtain, indeed, an *optimal* energy density of 1 J/cm^2 and *a good result* of cell stimulation or treatment.[3]

- wavelength of 635 nm
- continuous mode
- power 10 mW
- light spot area 1 cm^2
- exposure 100 sec

Let us consider other options with an identical result using the arithmetic operations described earlier (1 J/cm^2), but with no effect or even an inverse effect.

1. If power is 1 mW at an exposure of 1000 sec (or swapped: 1000 mW and 1 sec), no result will be obtained.
2. The optimal power is determined by the laser therapy technique and quite often is set in a very limited range. For example, for laser acupuncture, power of no >2–3 mW is used with a wavelength of 635 nm and a continuous mode. The same power range for the same wavelength is most often used for the intravenous laser blood illumination. The selection of the optimal power also directly depends on the wavelength, or rather, on

The Federal State-Financed Institution ''O.K. Skobelkin State Scientific Center of Laser Medicine under the Federal Medical Biological Agency,'' Moscow, Russia.

the absorption coefficient associated with it. The stronger the laser light is absorbed by the cells or tissues, the lower the power should be.

3. There is even more confusion while determining the optimal power parameters for various laser therapy techniques in a pulsed illumination mode, when the pulsed power is set in watts and dozens of watts, and the average power, therefore, energy density, linearly depends on the pulse repetition rate. By the way, variation in frequency is the best way to optimize laser exposure. We have developed relevant recommendations that could be introduced to the readers of the journal, if desired, and with the permission of the editorial board. The authors of the aforementioned article[1] are strongly advised to familiarize themselves with the laser anesthesia methodology and laser therapy techniques that work fine, although no energy or joules are mentioned in these procedures.[4]
4. The wavelength of the laser light is extremely important. If you choose 808 nm and a power of 10 mW, the result will not be obtained or will be completely minimal. If you choose the wavelength of 190 nm ultraviolet light (UVL), there may be problems, although the calculator will display the same 1 J/cm^2. There will certainly be no chance of stimulating the proliferation of the cells *in vitro* with such UV light.
5. Very often the laser beam is focused almost to a point with an absolutely incomprehensible goal (in my personal experience). What does this lead to? For example, if a light spot has a diameter of 1 mm, its area will be ~0.01 cm^2. In this case, to obtain the ''optimal'' energy density, it is necessary to reduce the power to 0.1 mW, and in the end, no results will be obtained. The topic of optimizing the illumination area is not simple; it requires a separate, more detailed publication (justification). However, it is more than safe to say that the minimum area should be ≥1 cm^2, and the maximum area is determined by the size of the illumination object. Everything is explained quite simply—the number of cells that fall into the illumination area is important, and it is not changed when the size of the light spot decreases below the specified limit. Therefore, it is pointless to engage in the division by this microscopic area.
6. Exposure is a parameter determined by biological (physiological) rhythms and is almost not subject to variation. This topic also requires a more detailed analysis. I hope the journal management will allow this to be done in the near future. Meanwhile, it can only be assumed that the optimal time for local illumination is 100 and 300 sec, and it is strongly prohibited to illuminate one zone for >5 min (300 sec). This requirement, such as all other conclusions, is a direct consequence of our proposed thermodynamic model of the LILI biomodulating action, according to which low-power low-energy laser light causes waves of increased calcium ion concentration in cells, which then spread throughout the cell, initiating Ca^{2+}-dependent processes. In all cell types, waves of increased Ca^{2+} concentration have constant periods of propagation (maxima) amounting to 100 and 300 sec. Accordingly, during illumination of some tissue or organ these waves simultaneously appear and synchronously propagate in all cells. It has been unambiguously proven that with an increased exposure time of 7–10 min, the effect disappears first, and then transforms into an inverse form—instead of the expected stimulation, inhibition occurs.[5]
7. The total time of the procedure (illumination of all laser-exposed zones) should not exceed 20 min.[6] This limitation is associated with the response time of the central nervous system, which responds to laser illumination with some delay. But as soon as the central regulatory mechanisms are activated in the process, illumination must be stopped.[3] Artificial ''general doses of treatment'' are in no way associated with the effective treatment.
8. For some techniques, the exposure time is strictly defined and not subject to variation. For example, laser acupuncture takes 20–40 sec per a corporal point.

Thus, if all the parameters of laser illumination are important (and they must be set separately, with optimal values selected for each of them), then why should one divide or multiply something by something? The manic perseverance of a huge number of people in using these absolutely meaningless calculation results is confounding. We are sure that someday everyone will understand the senselessness of such procedures.

We insist on the relationship of the laser therapy effectiveness (treatment efficacy) with all the parameters of the techniques, with each of them, and not with abstract values. However, the complex nature of biology requires interdisciplinary interactions. Finally, it should go without saying that incoherent light sources cannot be used in laser therapy, and it is impossible to equate completely different technologies.[5] More than 50 years of practical experience and thousands of fundamental studies led to the conclusions that are presented earlier.[4,7]

References

1. Kate RJ, Rubatt S, Enwemeka CS, Huddleston WE. Optimal laser phototherapy parameters for pain relief. Photomed Laser Surg 2018;36:354–362.
2. Finsen NR. On the use of concentrated chemical light rays in medicine. Leipzig: F.C.W. Vogel, 1899. [German].
3. Moskvin SV. Low-level laser therapy in Russia: history, science and practice. J Lasers Med Sci 2017;8:56–65.
4. Moskvin SV, Kisselev SB. Laser Therapy for Joint and Muscle Pain. Moscow–Tver: Triada, 2017.
5. Moskvin SV. Only lasers can be used for low level laser therapy. Biomedicine 2017;7:4–11.
6. Moskvin SV. The Effectiveness of Laser Therapy. Moscow: Triada, 2014. [Russian]
7. Moskvin SV, Khadartsev AA. Basic Techniques of Low Level Laser Therapy. Moscow–Tver: Triada, 2017.

Address correspondence to:
Sergey V. Moskvin, DBiolSci, PhDTechSci
NIC ''Matrix''
P.O. Box 33
Moscow 125367
Russia

E-mail: 7652612@mail.ru