Low-level laser therapy for sports horses

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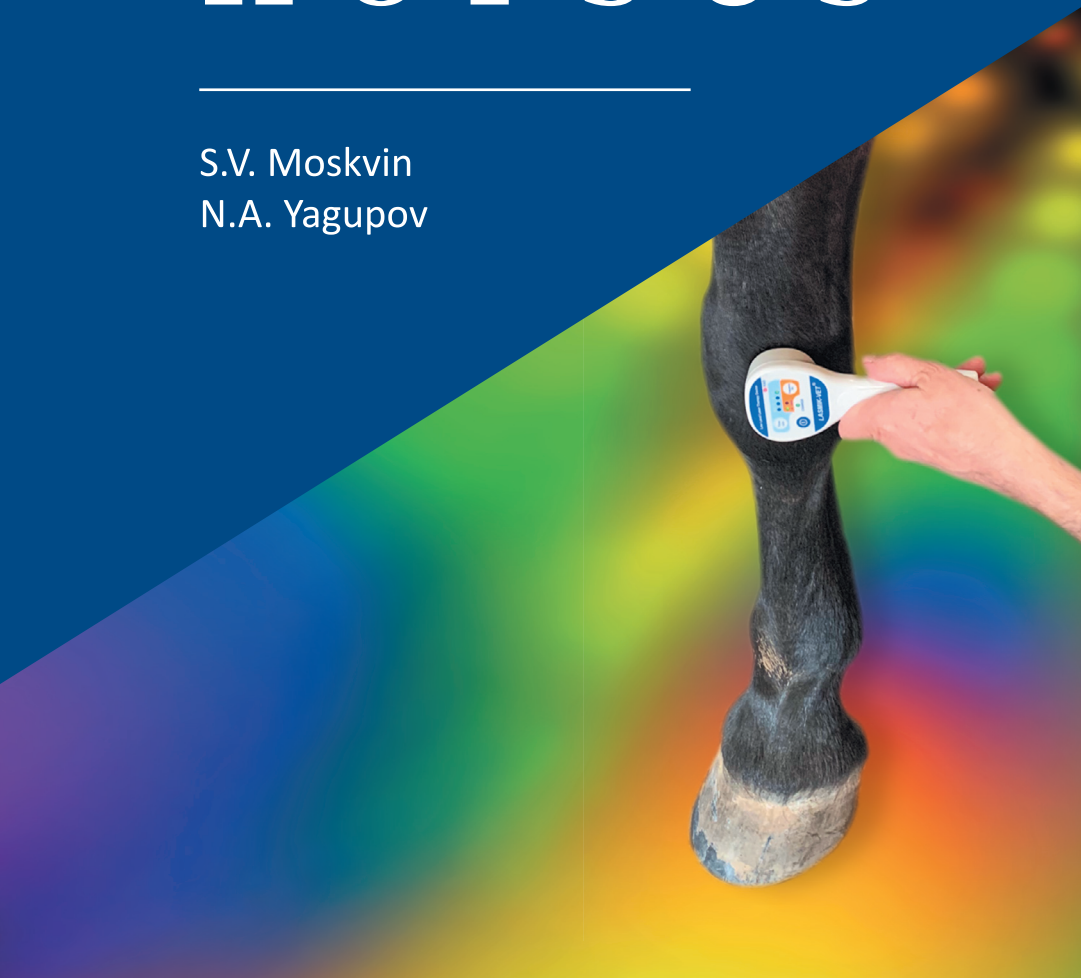

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LOW-LEVEL LASER THERAPY FOR SPORTS HORSES

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For more than 50 years, low-level laser therapy has been used successfully in medical and veterinary practice to treat domestic and farm animals. Sport horses are in special conditions; injuries and keeping them fit require special care. Low-level laser therapy devices are precious team helpers if they are used correctly. Optimal parameters and exposure localization should be carefully selected in each specific case.

Russia is the only country with a veritable scientific and practical school of low-level laser therapy. In-depth scientific rationale underpins the most effective techniques presented in the book. Low-level laser therapy is used for a wide variety of pathological conditions and diseases, and for stimulating equine performance and endurance: treatment of injuries and various diseases; stimulation of reproductive function in stallions; sport horse training to prepare for competitions; horses' stress-related issues due to transportation before competitions; and faster physiological recovery after the competitions.

Scientifically grounded methods of combined low-level laser therapy allow for the most efficient and convenient implementation of specially designed devices. LASMIK-VET is intended for external exposure to internal organs and laser blood illumination (wavelength 904 nm, pulsed mode, power 80 W), and LASMIK-AP is designed for laser acupuncture (wavelength 635 nm, power 10 mW).

The book, published in Russian and English, is intended for veterinarians, trainers, and equestrian sports specialists.

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LIST OF ABBREVIATIONS

AP	–	acupuncture point
BE	–	biological (biomodulating) effect
DOMS	–	delayed-onset muscle soreness
ED	–	energy density
EHF	–	extremely high frequency (range)
EMR	–	electromagnetic radiation
HA	–	hyaluronic acid
ILBI	–	intravenous laser blood illumination
IR	–	infrared (range, spectrum)
LD	–	laser diode
LED	–	light-emitting diode
LI	–	laser illumination
LILI	–	low-intensity laser illumination
LILL	–	low-intensity laser light
LLLT	–	low-level laser therapy
LUVBI	–	laser ultraviolet blood illumination
MLLLT	–	magnetic low-level laser therapy
MM	–	molecular mass
MSD	–	musculoskeletal disorders
MSS	–	musculoskeletal system
NLBI	–	non-invasive (supravascular, supravenous, percutaneous, transcutaneous) laser blood illumination
NO	–	nitrogen oxide
PD	–	power density
PRP	–	platelet-rich plasma
RCT	–	randomized controlled trial
ROS	–	reactive oxygen species
SOD	–	superoxide dismutase
UV	–	ultraviolet (range, spectrum)

INTRODUCTION

Horses are the noblest animals that have played a unique role in the history of humankind. For many centuries, they have been used as invaluable farm helpers, for transportation, and in land cultivation. In conditions of urbanization and technological progress, the attitude toward horses changed; they are now used mainly for active recreation and leisure. Today, there are many opportunities for horse riding and equestrian tourism. In addition, there are many therapies involving interactions with horses, such as therapeutic horseback riding, hippotherapy, and equine-assisted therapy and activities to improve patients' physical and mental health.

Naturally, horses get sick and injured, often because people do not observe the rules for working with them, impose unbearable requirements for them, violate equine work and recreation schedules, and are not skillful in handling males and females. Bad roads, uneven terrain that horses have to walk on, genetic predisposition, and much more can also lead to injuries.

According to statistics, lesions of the musculoskeletal system are the most common diseases in horses at 42% (includes neck diseases – 13%; thoracic spinal lesions – 19%; and lesions of other parts of the spine – 10%). Diseases of the gastrointestinal tract rank second (21%), and other diseases – 37%. The treatment of horses has its specifics, veterinarians should have high professionalism and the knowledge of anatomical and physiological features of these animals. Simultaneously, there are often no reliable and effective therapeutic techniques, and, unfortunately, an affected animal is rejected.

Additional difficulties and tasks exist when working with sport horses, including:

- ensuring effective training for competitions,
- reaching the peak of the form before races;
- stimulating equine performance and endurance;
- coping with stress related to horses' transportation before competitions;
- horses' recovery after the competition.

Obviously, all these activities should be carried out without causing even the slightest harm to the animal. In these cases, veterinarians can be aided by low-level laser therapy – an absolutely safe and extremely effective therapeutic and preventive method and a vital energy stimulator.

Additionally, we should note that although LASMIK-VET, a low-level laser therapy kit with nozzles, was developed for the maintenance care of sport horses, it also provides effective treatment for other domestic and farm animals.

Laser (LASER) is an abbreviation composed of the initial letters of the English phrase: Light Amplification by Stimulated Emission of Radiation. This greatest invention of the 20th century appeared thanks to Russian scientists,

laureates of Nobel Prize in Physics, N.G. Basov, A.M. Prokhorov and American C.H. Townes (1964). Later in 2000's, the Nobel Prize was awarded to Z.I. Alferov for the studies that formed the development of diode lasers. It is now impossible to imagine any science and technology industry where lasers are not used.

More than 50 years ago, laser light began to be used as a highly effective therapeutic agent in Russia for the first time. Today, low-level laser therapy (LLLT) is developing through the efforts of mostly Russian scientists and doctors, but it is becoming more widespread and recognized in other countries. For several decades, hundreds of treatment techniques and relapse prevention of various diseases in almost all areas of medicine have been developed in Russia. Therefore, it can be said that we have the most effective LLLT techniques and the best equipment in the world – we can be proud of our achievements!

The basis of the therapeutic effect of low-intensity laser illumination (LILI) is a thermodynamic launch of Ca^{2+}-dependent processes. This has allowed us to have a new look, not only at the problem of increasing the effectiveness of low level laser therapy, but also to look at the methodological approaches of the choice of treatment strategies as a whole. Now there is a deep scientific basis, which describes in detail the processes occurring in the absorption of low-intensity laser light, and we were able to develop the technology of low level laser therapy while abiding to a strict compliance with a certain sequence of operations, setting an initial set of parameters that almost certainly guarantee to provide the desired therapeutic effect. This allows professionals to understand how and what characteristics of the technique (wavelength, power and pulse repetition frequency of LILI, laser operational mode, exposure and localization) should be varied to enhance the effect.

The authors hope that this book will help in daily work, and any questions can be emailed to: 7652612@mail.ru.

GENERAL ISSUES OF LOW-LEVEL LASER THERAPY

Mechanisms of therapeutic effect of low-level laser therapy

The process of therapeutic effects of low-level laser illumination (coherent, monochromatic and polarized light) can be conventionally divided into three main stages:

1) primary effects (change of state of the electronic levels of the living matter of molecules, the stereo-chemical rearrangement of molecules, the local thermodynamic shifts and the emergence of an increased concentration of calcium ions in the cytosol);
2) secondary effects (propagation of waves of increased Ca^{2+} concentration in the cell, between cells, stimulation or inhibition of biological processes at a cellular level and changes in the functional state of individual biological cell systems and the body as a whole);
3) residual after-effects (formation of tissue metabolism products, response of the immune, endocrine and neurohumoral regulation systems, etc.).

All this variety of the developing processes determine the widest range of the body's responses to laser illumination. Fig. 1 shows virtually the entire sequence of events starting from the initial act of photon absorption and finishing with effects at the 'whole body' level. This explains numerous, if not all known phenomena in this field of biology and medicine.

It was previously shown that the initial starting moment of the biological effects of LILI is a local violation of the thermodynamic equilibrium, causing the release of calcium ions from the intracellular store and the propagation of waves with an increased concentration of Ca^{2+} in the cytosol of the cell, triggering Ca^{2+}-dependent processes [Moskvin S.V., 2003, 2008, 2014, 2016]. Then secondary effects develop, which are a complex of the non-specific adaptive and compensatory reactions that occur in the tissues, organs and entire living body, among which the following: effects are distinguished most often:

- activation of the cell metabolism and increase in its functional activity,
- stimulation of reparative processes,
- anti-inflammatory effect,
- activation of blood microcirculation,
- increase in tissue trophic support,
- analgesic and immunomodulatory effect,
- reflexogenic impact on the functional activity of various organs and systems.

Numerous studies have shown that LILI acts as an activator of cellular responses aimed at restoring and normalizing the bioenergetic status of the body's tissues and immune system. LILI increases enzymatic and catalase activity,

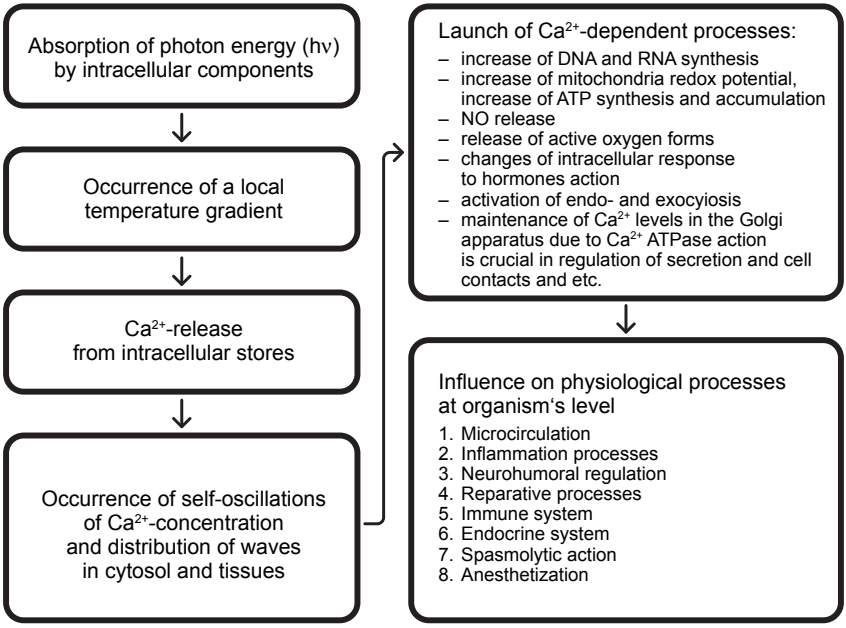

Fig. 1. The sequence of development of biological effects after exposing living bodies to LILI

permeability of the cytoplasmic membranes, contributing to the acceleration of metabolic and transport processes in tissues. Accelerated oxygen exchange reduces hypoxia accompanying inflammatory processes.

LILI activates the regenerative processes in pathological conditions (trauma, surgical procedures, transplantation) due to changes in the cellular composition in the area of the wound or ulcer by increasing the number of neutrophils, as well as by accelerating the growth of capillaries and accumulating collagen produced by them, which determines the speed and quality of wound or ulcer surface epithelialization. In addition, hormonal and neurotransmitter components of the adaptive mechanism are activated. An increase in non-specific immunity of the body after LILI exposure is confirmed by the rising titer of hepagglutinin, hemolysins, lysozyme, activation of neutrophils and interferons, increased synthesis of immunoglobulins and changed function and structure of plasma membranes and increase in the number of lymphocyte blast forms.

Laser illumination reduces the concentration of lipid peroxidation products in the blood, enhancing the antioxidant system, increases the level of catalase, activates the cellular elements of mononuclear phagocytes (macrophages) that

stimulate cell proliferation and accelerates restoration of morpho-functional state of the cell membranes.

In development of the body response an important role is played by the impact of LILI on the blood, exerting a beneficial complex (systematic) influence caused by common hemocirculation. Studies using vital microscopy, computer capillaroscopy and photographic recording showed an increase in the number of functioning capillaries, acceleration of blood flow and normalization of microcirculation in general. Central hemodynamics is changing as well; it is proved that LILI has venomotor and artery dilation effects in case of initially decreased indicators.

Low-level laser therapy, conducted before the start of any surgery intervention in order to prevent infiltration and suppuration, improves local blood circulation, metabolism, oxygenation and maintenance of the trophic support of tissues, which stabilizes the postoperative course, reducing the probability of developing complications by several times.

LILI's ability to increase the content of neurohormones in tissues, to involve various specific proteins of cell membranes in the process which activate enzymes such as adenocyclase, adenylate cyclase, denyl cyclase, phosphodiesterase and calcium ions, altering the intra- and extracellular metabolism, to affect sensitive components of intercellular spaces leads to the normalization of the local and general physiological response, contributes to the preservation or restoration of homeostasis and body adaptation to stress conditions.

Equipment for Low-level Laser Therapy

A variety of techniques and applications of low-level laser therapy devices require maximum versatility of the equipment used to ensure maximum efficiency of the therapeutic effects, which, in turn, is ensured by the following procedures:

- (separate) use of LILI with different wavelengths;
- operation in modulated and pulsed modes;
- external illumination modulation (BIO mode, modulation by musical rhythm, etc.);
- illumination delivery with minimal losses through the light guides (ILBI, abdominal procedures);
- optimal spatial distribution of the laser illumination (providing optimum power density);
- reliable and continuous monitoring of the impact parameters.

The proposed modular design concept allows the successful solving of all of these tasks, according to which the laser therapeutic equipment is conventionally divided into four mating parts (Fig. 2): 1 – the base unit (usually 2 – and 4-channel); 2 – laser emitting heads for different low-level laser therapy techniques; 3 – optical and magnetic nozzles; 4 – Matrix-Bio biocontrol unit.

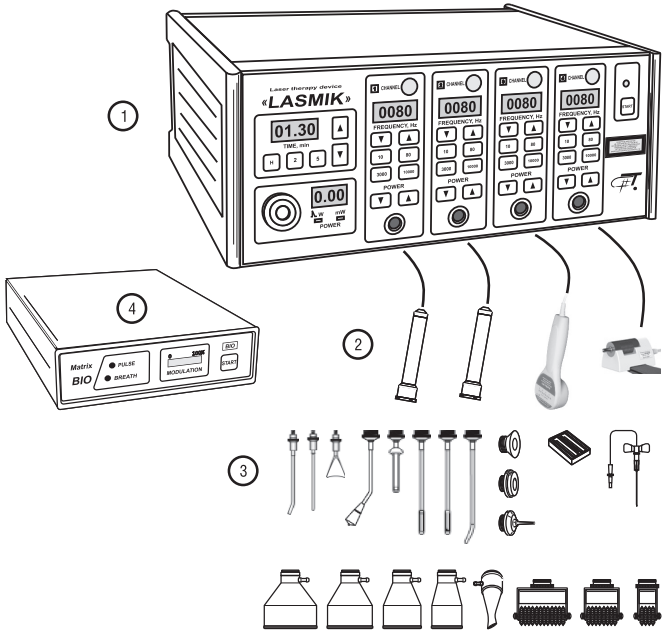

Fig. 2. The modular design concept of low-level laser therapy equipment as exemplified by the Matrix and LASMIK series, where: 1 – the base unit (usually a 2-channel and 4-channel); 2 – laser emitting heads for various LLLT techniques; 3 – optical and magnetic nozzles; 4 – the biocontrol unit Matrix-BIO

The base unit is the basis of each set; it is a power supply and control unit. Its main functions include setting emission modes with mandatory control of the parameters: frequency, session time, beam output power, etc.

Control of parameters not only insures against errors in selecting the initial values, but also provides the possibility of varying the exposure modes in a wide range, which, in turn, allows professionals to provide optimal treatment options.

Laser emitting heads of various types with the appropriate nozzles (magnetic and optical) are connected to the base unit. In the advanced equipment, a provision is made for the external modulation of beam output power of heads, for example, by the patient‘s biorhythms.

Laser therapeutic devices of the Matrix and LASMIK series are effective, easy to operate, have a modern design, enabling them to be applied successfully in the best medical centers. In addition, based on these devices, it is possible to create highly efficient specialized complexes, which have already proved themselves as the best. Find more detailed information in a color inset.

The peculiarities of Applying Various Low-level Laser Therapy Techniques

Low-level laser therapy (LLLT) is a physiotherapy method, using electromagnetic illumination in the optical range – coherent light or low-level laser illumination (LLLI), generated by special sources. These lasers are a healing factor. The main properties of laser light are the monochromaticity, coherence, polarization and directionality, due to which low-level laser therapy, being a kind of physiotherapeutic light exposure, has unique healing properties and methodological features of practical application.

Monochromaticity (Greek monos – one, single, the only + chroma – color, paint) means illumination in a very narrow range of wavelengths. Illumination within a spectral width of less than 3 nm may be taken conventionally as monochromatic. This property offers the opportunity for selective action on the structural components of tissues and cells, triggering an entire cascade of primary biochemical and biophysical processes.

Coherence (Latin "cohaerens" – the state of being connected, related) is a consistent progress of several oscillatory wave processes of the same frequency and polarization in time and/or space.

Polarization is symmetry in the distribution of the orientation of electric and magnetic field vectors relative to the direction of the electromagnetic wave propagation. If two mutually perpendicular components of the electric field vector oscillate with a time-constant phase difference, this wave is polarized.

Directionality is an important property of laser illumination, enabling, if necessary, to obtain a higher power density (of incident energy) in comparison to other light sources.

The average capacities of physiotherapeutic lasers are often within the ranges of 1–100 mW, pulse power varies from 5 to 100 W with duration of light pulses being 100–130 ns (~ 10^{-7} s). The nature of the primary photobiological reactions is determined by the energy of quanta of optical illumination of less than 2eV on the red and near-infrared spectra; however, it is sufficient to enhance the oscillatory processes of molecules, initiating numerous secondary biophysical and biochemical processes. At present, an increasing number of scientific publications are devoted to the study of the effectiveness of LILI on the ultraviolet and green spectra with higher energy of quanta.

There are many randomized controlled trials (RCTs) by a number of researchers that are based on the data that irrefutably proved the diverse medicinal properties of LILI are defined by the following effects [Moskvin S.V., 2014, 2016]:

- microcirculation activation;
- immunomodulatory and anti-inflammatory effect;
- analgesic effect;

– tissue proliferation and regeneration activation;
– diversified action on the nervous tissue, including reflex action.

Low-level laser therapy has found widespread application in clinical practice; this method is widely used in almost all fields of modern medicine. There is a large amount of factual material, confirming its high efficacy in the treatment of patients with diseases of the musculo-skeletal, cardiovascular and nervous systems, as well as diseases of the ear, nose and throat, and also in the rehabilitation of patients after injuries and surgery. At the same time there is a discrepancy in the recommended LILI parameters, making it difficult for clinicians to select the most effective technique in terms of evidentiary medicine. Only a deep and comprehensive analysis of RCTs carried out by domestic and foreign researchers with an objective assessment of the results of the low-level laser therapy course will help improve the quality of medical services.

Low-level Laser Therapy Protocol Requirements

Fulfilling all the requirements for the implementation of the low-level laser therapy protocols is mandatory, since the need to set all the parameters of methods listed below is clearly proved. Even one wrong value will not allow getting a predictable and adequate response to laser light action and the desired therapeutic effect, respectively.

Setting energy parameters substantially depends on the laser operating mode and technique. A majority of Russian devices have a laser hazard Class 1M or 2M according to IEC 60825-1: 2007, while foreign lasers mainly have the laser hazard Class 3R, which greatly complicates their application. Moreover, most cases require minimal energy of LILI to successfully implement low-level laser therapy techniques, and increased power and exposure (energy) can result in an inhibitory effect, i.e. complications.

All techniques of low-level laser therapy must contain the following information.

1. Laser light wavelength as measured in nanometres [nm] (The International System of Units (SI), 8th edition. – Bureau International des Poids et Mesures, 2006.). The most wide-spread LT spectral ranges are:
– 365–405 nm – ultraviolet (UV) spectrum;
– 440–445 nm – blue spectrum;
– 520–525 nm – green spectrum;
– 635 nm – red spectrum;
– 780–785 nm – infrared (IR) spectrum;
– 890–904 nm – infrared (IR) spectrum.

It is inadmissible to illuminate one and the same area simultaneously with lasers having different wavelengths or incoherent light sources due to inhibiting interference.

2. Laser operational mode: continuous, modulated, pulsed.

3. Beam output power.

The average power of continuous lasers operating in continuous and modulated modes is measured in milliwatts [mW], the impulse (peak) power of pulsed lasers is measured in watts [W].

4. The modulation frequency or pulse repetition frequency for pulse mode is the number of vibrations (pulses) per unit time (second). It is measured in hertz [Hz, 1/s].

5. The most important parameter of pulsed lasers is the duration of the light pulse, it is a constant (most commonly 100–150 ns). The average power of pulsed lasers (Pav.) is directly proportional to the pulsed power (Pp), pulse duration (τp) and frequency (Fp): Pav. = Pp × τp × Fip.

6. Illumination area is measured in square centimeters [cm^2].

The required area is almost always provided by the procedure without carrying out unnecessary measurements, for example, in contact-mirror method the area is assumed to be 1 cm^2. In matrix emitters laser diodes must be positioned so that the area of theirimpact would provide the multiplicity in power density. For example, 8 (most often) pulsed laser diodes having a power of 10W shall be disposed on the surface of 8 cm^2, and in contact with the skin through a transparent tip PD will be 10 W/cm^2, respectively. During laser acupuncture or intravenous laser blood illumination (ILBI) the area is not specified, as the exposed zone is too small, and the leading role is played by scattering and absorption of the laser light energy in the volume of biological tissues.

7. Power density (PD) is measured in watts (for pulsed lasers) or milliwatts per square centimeter [W/cm^2 or mW/cm^2].

8. The exposure (the exposure time) per one zone and total time for the procedure are measured in seconds [s] or minutes [min].

9. Localization of action (technique), the exposed zones should be specified.

10. The number of procedures per course and their frequency.

Calculations of energy, which is measured in Joules [J or W·s] or energy density [J/cm^2 or $W·s/cm^2$] shall not be carried out, because this information is not necessary to provide effective low-level laser therapy (Tables 1–7).

It is recommended to include one of the methods of overall impact into the protocol (laser acupuncture or ILBI), and the methods for directly illuminating the affected area by zones (local, transcutaneous or abdominal procedures, as well as the combined method – laser phoresis).

Local LILI is administered directly on the affected area, located close to the surface of the body, either through direct contact through the mirror nozzle or by distance, in a stable manner, at a short distance from the surface (1–2 cm), if it is impossible to provide direct contact. Sometimes a combined physiotherapy method – magnetic low-level laser therapy (MLLLT) – is used with a laser

beam acting through the opening of a permanent magnet, with an induction of 35–50 mT [Moskvin S.V., 2016].

The following procedures are used most often for local laser exposure:

– continuous LILI of the red spectrum (635 nm), PD – 10–15 mW/cm^2;
– pulsed LILI of the red spectrum (635 nm), PD – 4–5 W/cm^2, pulse duration of 100–150 ns, frequency of 80–10,000 Hz;
– pulsed IR LILI (890–904 nm), PD – 8–10 W/cm^2, pulse duration of 100–150 ns, frequency of 80–10,000 Hz.

The frequency for *pulsed lasers* varies depending on the desired effect: regeneration – 80–150 Hz, anesthesia – 3,000–10,000 Hz. One area includes up to 2–3 local zones, the exposure for each zone being 2–5 minutes. It is strictly forbidden to illuminate one area for more than 5 minutes.

Local action of LILI on the projection of the affected organ of body differs from surface illumination, as only pulsed infrared lasers are used, and matrix lasers are desirable to ensure a therapeutic effect at a depth of 15 cm: wavelength 890–904 nm, PD – 8–10 W/cm^2, pulse duration of 100–150 ns, frequency of 80–10,000 Hz (Table 2). By increasing the frequency in pulsed lasers, the average illumination power increases proportionally as well, which allows the influencing of deeper areas. It is strictly forbidden to illuminate one area for more than 5 minutes.

Table 1

Parameters of contact-mirror and distant low-level laser therapy techniques

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	445 (blue), 525 (green), 635 (red), 780, 808, 904 (IR)	Emitting head with one laser
Laser operational mode	Continuous	445, 525, 635, 780, 808 nm
	Pulsed	635 and 904 nm
Duration of the light pulse, ns	100–150	For pulsed mode
Power	10–40 mW	Continuous mode
	5–25 W	Pulsed mode
Power density (More absorption – less value)	5–40 mW/cm^2	Continuous mode
	5–15 W/cm^2	Pulsed mode
Frequency, Hz	80–150	For pulsed mode
Exposure per one zone, min	2 or 5	–
Number of the exposed zones	1–4	–
Localization	On affected area	–
Technique	Contact-mirror	With the use of a mirror (ZN-35 or ZN-50) or magnetic nozzle ZM-50 (Fig. 3)
Number of procedures per course	5–12	Daily or on alternate days

Table 2

Parameters of contact technique for matrix laser emitting heads

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	635 (red)	–
	904 (IR)	
Laser operational mode	Pulsed	Matrix emitter consisting of 8 laser diodes of the total surface area of 10 cm^2
Duration of the light pulse, ns	100–150	For pulsed mode
Power, W	35–40	635 nm
	60–80	904 nm
Power density, W/cm^2	4–5	635 nm
	8–10	904 nm
Frequency , Hz	80–10 000	Depending on the depth of the intended exposure and wavelength
Exposure per one zone, min	1,5–2 or 5	–
Number of the exposed zones	1–4	–
Localization	On the affected area and the projection of the internal organs	–
Technique	Contact	Through a transparent nozzle PMN
Number of procedures per course	5–12	Daily or on alternate days

Table 3

Parameters of contact low-level laser therapy technique

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	780, 808, 904 (IR)	Emitting head with one laser
Laser operational mode	Continuous	780 nm and 808 nm
	Pulsed	904 nm
Duration of the light pulse, ns	100–150	For pulsed mode
Power	100–200 mW	780 and 808 nm
	80–100 W	904 nm
Power density	–	The maximum possible
Frequency , Hz	3000–10 000	For pulsed mode
Exposure per one zone, min	5	In some techniques exposure is allowed up to 30 min
Number of the exposed zones	1–4	Most often symmetrically
Localization	On affected area	–
Technique	Contact	Directly touching the surface with the laser diode
Number of procedures per course	15–20	Generally, daily. The course is repeated in a month

Laser acupuncture (laserpuncture) is carried out by means of a special acupuncture nozzle designed for concentrating the laser light energy into a zone of 1–2 mm in diameter. The wavelength is 635 nm (red spectrum), continuous or modulated modes are used, nozzle output power is 2–3 mW, exposure per one corporal acupuncture point (AP) ranges from 20 to 40 s, making it 5–10 s per auricular acupuncture point (AP).

Table 4

Parameters of laser acupuncture technique

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	525 (green)	On auricular AP
	635 (red)	On corporal AP
Laser operational mode	Continuous or modulated	–
Frequency, Hz	In a recipe	Only for modulated mode
Power*, mW	0,5–1	525 nm
	2–3	635 nm
Exposure per 1 AP, s	5–10	On auricular AP
	20–40	On corporal AP
Number of the exposed zones	Up to 15	–
Localization	In a recipe	On auricular AP
	In a recipe	On corporal AP
Technique	Contact	Through an acupuncture nozzle
Number of procedures per course	10–12	Daily

Note. * – at the output of an acupuncture nozzle.

Laser blood illumination provides for two options for a procedure: via intravenous or non-invasive (extravenous, external, percutaneous, transcutaneous) access. Accordingly, these are called intravenous laser blood illumination (ILBI) and non-invasive (extravenous, transcutaneous, percutaneous) laser blood illumination (NLBI).

The Matrix and LASMIK devices (Fig. 3) allow carrying out both intravenous and non-invasive laser blood illumination, as well as other methods of laser exposure. The maximum effectiveness of treatment is also based on the optimized design of the laser heads, e.g. a special system of fixing disposable light guides and the heads on the arm is used for ILBI (Fig. 3, bottom left), matrix emitting heads are used for NLBI (Fig. 3, bottom right, and Fig. 4).

For ILBI, the LILI is always used in continuous mode, laser action is carried out intravenously through special disposable sterile light guide with a puncture needle (Fig. 5) most often in the cubital vein [Geynits A.V., Moskvin S.V., 2009; Geynits A.V. et al., 2012].

Fig. 3. Laser therapeutic device "LASMIK"

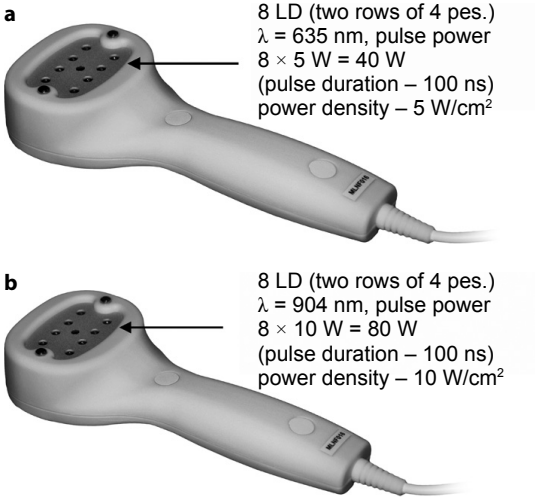

Fig. 4. Matrix laser emitting heads ML-635-40 (a) and ML-904-80 (b)

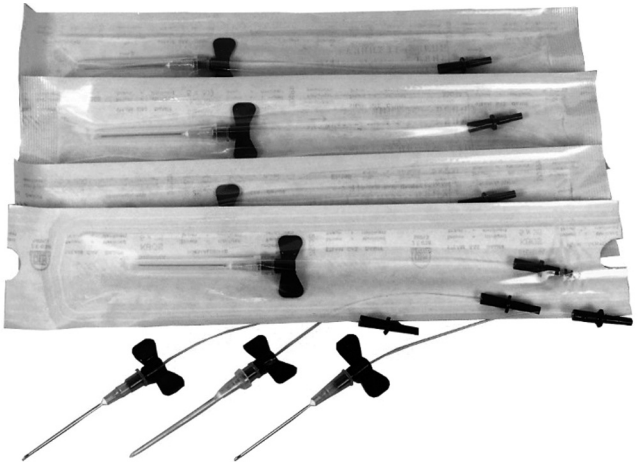

Fig. 5. Disposable sterile light guides for ILBI

To implement ILBI, different techniques are currently applied using laser light of different spectra (Tables 5, 6):

ILBI-635 (wavelength 635 nm, red spectrum, power 1.5–2 mW, exposure for 10–20 minutes) has a universal effect, making a positive impact both on the immune system, and provides the trophic support of tissues.

ILBI-525 (wavelength 525 nm, green spectrum, power 1.5–2 mW, exposure of 7–8 minutes) is recommended to ensure maximum gain of trophic support of tissues.

Table 5

Parameters of ILBI-525 + LUVBI® technique (basic)

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	365–405 (UV)	LUVBI®
	520–525 (green)	ILBI-525
Laser operational mode	Continuous	–
Power, mW	1,5–2	At the output of a disposable light guide
Exposure , min	3–5	LUVBI®
	7–8	ILBI-525
Localization	Median cubital vein (*v. mediana cubiti*)	–
Technique	Intravenously	Through a disposable sterile light guide
Number of procedures per course	10–12	Daily, alternating ILBI-525 and LUVBI® every other day

Table 6

Parameters of ILBI-635 + LUVBI® technique

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	365–405 (UV)	LUVBI®
	635 (red)	ILBI-635
Laser operational mode	Continuous	–
Power, mW	1,5–2	At the output of a disposable light guide
Exposure , min	3–5	LUVBI®
	10–20	ILBI-635
Localization	Median cubital vein (*v. mediana cubiti*)	–
Technique	Intravenously	Through a disposable sterile light guide
Number of procedures per course	10–12	Daily, alternating ILBI-635 and LUVBI® every other day

Laser ultraviolet blood illumination (LUVBI®, wavelength 365–405 nm, power 1.5–2 mW, exposure of 3–5 minutes) should be preferably used for the correction of immune disorders of various etiologies.

Non-invasive laser blood illumination (NLBI) is carried out on large blood vessels, adjacent to the center of the lesion focus. Pulsed lasers, preferably of the red (635 nm) and infrared (890–904nm) spectra and matrix emitters (8 laser diodes) or, as an option, a single laser with a mirror nozzle are used mainly for NLBI (Table 7) [Moskvin S.V. et al., 2007]:

- pulsed LILI of red spectrum (635 nm), PD – 4–5 W/cm^2, pulse duration of 100–150 ns, frequency of 80 Hz;
- pulsed infrared LILI (890–904 nm), PD – 8–10 W/cm^2, pulse duration of 100–150 ns, frequency of 80 Hz.

The following exposure localizations are used for NLBI (Fig. 6):

- projection of the common carotid artery (sinocarotid zone) symmetrically (zone 2);
- projection of the vertebral artery symmetrically (zone 3);
- left supraclavicular area (zone 4);
- vascular bundles in groin symmetrically (zone 5);
- popliteal fossa symmetrically (zone 6).

Pulse repetition frequency is fixed (80–150Hz), the question of possibility and admissibility of increasing the frequency (i.e. the average power for pulsed lasers) has not been studied at present. It is recommended to illuminate symmetrical zones, the exposure for each zone needs to be 2–5 minutes. It is strictly forbidden to illuminate one area for more than 5 minutes!

Table 7

Parameters of NLBI technique

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	635 (red)	NLBI-635
	904 (IR)	NLBI-904
Laser operational mode	Pulsed	–
Duration of the light pulse, ns	100–150	–
Power, W	30–40	Matrix emitting head, NLBI-635
	60–80	Matrix emitting head, NLBI-904
Power density, W/cm^2 (surface area 10 cm^2)	3–4	NLBI-635
	6–8	NLBI-904
Frequency, Hz	80–150	–
Exposure per one zone, min	2–5	–
Number of the exposed zones	2–4	Symmetrically
Localization	On the projection of large blood vessels close to the lesions	Refer to the text
Technique	Contact	Through a transparent nozzle
Number of procedures per course	10–12	Daily

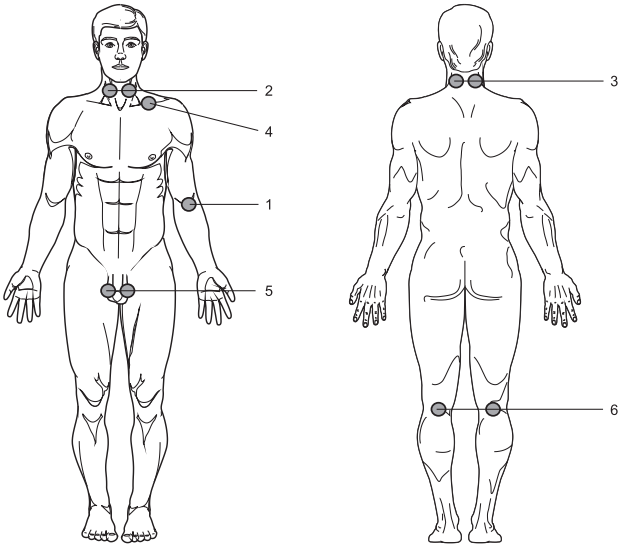

Fig. 6. The basic zones for laser blood illumination in humans

The Intracavitary procedure is intended to deliver laser light energy to the affected area, located in a natural cavity (endonasal, endoauricular, etc.), via a special light guide instrument (optical fiber). A feature of this procedure is the need to introduce most of the energy in the fiber, followed by its distribution inside along the given indicatrix, however, since PD is not always determined in this case, the illumination power is set at the nozzle inlet, i.e. is measured without the nozzle. The following procedures are used most often for laser exposure:

- continuous LILI of the red spectrum (635 nm), power – 10–15 mW,
- pulsed LILI of the red spectrum (635 nm), power – 4–5 W, pulse duration of 100–150 ns, frequency of 80–150 Hz,
- pulsed infrared LILI (890–904 nm), power – 15–20 W, pulse duration of 100–150 ns, frequency of 80–10,000 Hz.

To deliver pulsed IR LILI (890–904 nm), it is required to use only the quartz-polymer fiber, as the polymer (PMMA) absorbs nearly all the illumination with wavelengths longer than 830 nm. It is strictly forbidden to illuminate one area for more than 5 minutes.

Laser phoresis is one of the more modern practices of physical and pharmacological methods of the combined percutaneous application of LILI and medicinal preparations. As a result of LILI, the area which is previously applied with the biologically active substance in the form of gel or an aqueous solution, its penetration through skin (pores, hair follicles) is activated. This percutaneous injection-free method of substance administration is possible only with low molecular weight (no more than 500kDa) and hydrophilic compounds [Moskvin S.V., Konchugova T.V., 2012].

The parameters of the technique:

- continuous LILI of the red spectrum (635 nm), PD – 10–15 mW/cm^2,
- continuous infrared LILI (780–790 nm), PD – 40–50 mW/cm^2,
- pulsed infrared LILI (890–904 nm), PD – 8–10 W/cm^2, pulse duration of 100–150 ns, frequency of 80 Hz.

For pulsed lasers frequency is not changed. One area may have up to 15–20 local areas, with an exposure time of 1–1.5 minutes for each zone, but no more than 20 minutes in total.

The presented principles of the low-level laser therapy procedures formation may be adjusted in some cases, except for the exposure. Varying the exposure time is not allowed, because it is determined by physiological rhythms, synchronization with which necessarily underlies any laser treatment techniques. In some cases, it is possible to adjust LILI energy parameters, for example, for pain relief or suppression of excessive proliferation it is required to set up extremely high frequencies – up to 10,000Hz (recommendation refers exclusively to the pulsed lasers with pulse duration of 100–200 ns and pulsed (peak) output power up to 300 W).

LASMIK-VET, a laser therapy kit for veterinary medicine

Initially, LASMIK-VET was developed to specifically treat and rehabilitate horses and maintain their fitness. Still, the capabilities of the devices are much greater, allowing for the most effective treatment of other domestic and farm animals.

The kit includes two low-level laser therapy devices with an autonomous battery power supply.

"LASMIK-VET" (Fig. 7)

Fig. 7. Laser therapeutic device "LASMIK-VET" – view from the control panel

The device is a matrix pulsed laser, an analogue of the ML-904-80 laser emitting head for "Matrix" and "Lasmik" laser therapeutic devices. It contains 8 laser diodes (LD) arranged in two rows (Fig. 4).

It is intended for local exposure, in the projection of internal organs, non-invasive laser blood illumination (NLBI), etc. It is possible to combine with a magnetic attachment for the implementation of magnetic low-level laser therapy.

Main technical characteristics of the device:
- wavelength – 904 nm;
- operating mode – pulsed;
- light pulse duration – 100 ns;
- power – 80 W;
- number of laser diodes – 8 pcs.;
- frequencies: 80 and 10,000 Hz;
- timer: 0.5, 1, 2, 5 min;
- device weight – no more than 0.5 kg;
- intermittent operating mode – 10 min (5 + 5) with a break of 10–15 minutes;
- service life – 5 years;
- warranty period – 5 years.

"LASMIK-AP" (Fig. 8)

Fig. 8. Laser therapeutic device "LASMIK-AP"

It is designed for laser acupuncture (with A-3 attachment), but can also be used for local illumination, for example, of wounds or trauma.

Main technical characteristics of the device:
- wavelength – 635 nm;
- power – 5–10 mW;
- number of laser diodes – 1 pc.;
- mode of operation – continuous work;
- timer – 30 s.

Optical and magnetic attachments

Acupuncture nozzle A-3 – 1 pc.
PMN nozzle (transparent protective) – 1 pc.
Mirror attachment ZN-35 – 1 pc.
MM-50 attachment (magnetic 50 mT) – 1 pc.
ZM-50 attachment (magnetic 50 mT) – 1 pc.

Additionally

Charger – 1 pc.

Charging cord – 2 pcs.

Book “Low-level laser therapy for sports horses” (in Russian and English) – 1 set.

Book “Low-level laser therapy for domestic animals” (in Russian and English) – 1 set.

Bag (fig. 9) – 1 pcs.

Fig. 9. Bag for storage and transportation of the devices and nozzles

Quite often, customers also purchase LASMIK laser therapeutic device with KL-ILBI-525-2 and KL-ILBI-365-2 laser emitting heads for intravenous laser blood illumination in addition to kit to implement the most effective version of the combined technique ILBI-525 + LUVBI® (see Fig. 3). This therapy is very actively applied to sport horses during the non-competition period, and it is also used in veterinary clinics to treat domestic animals.

Our specialists provide consultations via email concerning the application of low-level laser therapy in veterinary medicine: 7652612@mail.ru

LOW-LEVEL LASER THERAPY IN VETERINARY MEDICINE

Lasers began to be used in veterinary medicine much earlier than laser therapy practice in humans. If for no other reason, the first trials, which revealed the bio-modulatory properties of low-intensity laser illumination (LILI), were done on animals. Low-level laser therapy techniques were also practiced in animals; later, these techniques were used in the clinic. The study of the mechanisms of laser light biological effect (BE) continues.

Although most often rats and less often mice were used as a master model, for example, when studying the process of muscle recovery (regeneration) after injury [Albuquerque-Pontes G.M. et al., 2018; de Brito A. et al., 2018; De Lima Rodrigues D. et al., 2018; Tomazoni S.S. et al., 2017, 2017(1)], when treating experimental arthritis [Issa J.P.M. et al., 2017; Tomazoni S.S. et al., 2017(2)] and wounds [Al-Watban F.A.H. et al., 2007; Tatmatsu-Rocha J.C. et al., 2016]. Other animals also took part in the trials, including rabbits [Nicolopoulos N. et al., 1996], dogs [Miller L.A. et al., 2020; Ocaña-Quero J.M. et al., 1998], hamsters [Campos L. et al., 2016], cats [Yatskevich T.L. et al., 2017, 2017(1)], cows (calves) [Borisov N.A., 2007; Golubtsov A.V., Vasilisin V.V., 2010], sheep (rams) [Bekkuliev K.M. et al., 2015; Iacopetti I. et al., 2015], chickens [Kabisov V.E., 2011], etc. Publications on the treatment of horses are discussed in separate chapters of our book.

Authors publishing experimental papers have contributed significantly to the development of low-level laser therapy. But, in recent years, there has been an extremely negative trend: actual low-level laser therapy is substituted for amorphous "photobiomodulation" (PBM) when ineffective bulbs and light-emitting diodes (LEDs) are used instead of coherent light sources [Porter M., 1998].

Well-illustrated books by German authors, in which the term "laser therapy" appears in the title, contain nothing of the kind. All techniques, without added explanations and comments, are reduced to two parameters: the number of procedures and "doses" (J/cm^2). To be more precise, they give only examples: 7 J means 35-s exposure on a point at 200 mW; 8 J stands for 40-s exposure on a point at 200 mW; and so on. It is recommended to expose acupuncture points to a "dose" of 6 J, that is, illuminating them with laser light for 30 s at 200 mW. Indeed, 500-mW power is mentioned in the calculation tables! This is entirely unacceptable. An ineffective continuous mode (a specific "maximum penetration" range of 780–800 nm), is used at an unknown wavelength [Füchtenbusch A., 2015; Füchtenbusch A., Rosin P., 2015]. The acupuncture schemes (prescriptions) proposed by A. Füchtenbusch and P. Rosin (2015) are likely to "work" even without very effective LILI parameters. However, we should repeat that these German books just do not deal precisely with low-level laser therapy as an effective treatment method, since they do not describe any techniques.

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