recharge health

WHITE PAPER – FLEXBEAM, TARGETED RED LIGHT DEVICE

Definition of FlexBeam

The FlexBeam device is a portable Photobiomodulation (PBM) device that emits non-coherent red and near infrared light via use of LEDs. FlexBeam is a wellness device. US FDA class II, MD class IIa are pending and subject to a submission.

Description

FlexBeam dimensions are 35cm x 13.5cm x 4cm. The 3 light modules plus one battery module are connected by a flexible silicon material allowing the device to be wrapped around a limb. In addition, it can be used flat on the body secured by using the provided straps where necessary. This enables treatment on any area of the body and, in the case of wrapping around a limb, treatment from multiple angles.

The device comprises 6 Near infrared (NIR) LEDs at 815nm ± 15nm (3 modules, 2 LEDs/module) and 3 red LEDs at 625-635nm (3 modules, 1 LED/module). The LED's are high quality with a 90-245V AC input power supply with 15V, 2.4A output. Peak wavelength 630 nm in red and 815 nm in near infrared. When in contact, it irradiates 40 cm2 of skin per module, a total of 120 cm2. The key technical parameters of FlexBeam were calculated with a consideration of fluency, dose of energy and bi-phasic dose response.

When in skin contact the FlexBeam has a maximum power output of 100mW/cm2 in the NIR LEDs and 50mW/cm2 in the red LEDs. The device operates in pulsing mode with pulsing frequencies between 10-1000Hz and duty cycle of 10-100% with 10-minute intervention time.

All the skin-contacting materials used in the device meet ISO 10993 requirements for biocompatibility for cytotoxicity, sensitization, and irritation.

FlexBeam is powered by a rechargeable Li-ion battery contained in the battery module with one charge lasting for up to 1.5 hours. This module also contains the user interface for turning on and shutting down the device, program selection and indication of the state of charge. The device contains an active fan cooling system to regulate temperature and automatic shutdown at the completion of each treatment. It is also programmed to shut down in the case of overheating or overcurrent faults to ensure user safety.

The intended use of FlexBeam is directly to the skin, anywhere in the body. It is not designed to treat the head. Once achieved 510k exemption (November 2021) The FlexBeam will be an over-the-counter device intended for the temporary relief of minor muscle and joint pain, arthritis, and muscle spasm; relieving stiffness; temporary relaxation of muscle tissue and to temporarily increase local blood circulation.

The FlexBeam emits non-coherent Red, and Near-infrared (NIR) light and its effects are accomplished through an optimization of mitochondria functioning and an increase in microcirculation stimulated by this light. Additional associated benefits are faster recovery rate from physical performance, increased energy level, and improvement of general wellbeing and sleep.

The patient is the intended operator - users will treat themselves with the device.

Photobiomodulation

Photobiomodulation (PBM) is a use of non-ionizing, non-heating light sources for therapeutic use. PBM is also known as Low-Level Laser Therapy (LLLT) and was often referred to this term in the past. PBM uses either coherent light sources (lasers) or non-coherent light sources consisting of filtered lamps or light-emitting diodes (LED) or, on occasion, a combination of both and are regarded as PBM.

Light application is usually a low power in the range of 1mW – 500mW. This electromagnetic radiation is typically of a narrow spectral width in the red or near infrared (NIR) spectrum (600nm – 1000nm), with a power density (irradiance) between 1mW-5W/cm.

PBM established its clinical efficacy over the past 50 years as a tool to promote tissue regeneration, reduce inflammation and relieve pain. Michael Hamblin (PhD)[1] a main researcher of PBM states, "for several decades, it was believed that coherent laser light was necessary, but as of today, non-coherent light sources such as light emitting diodes (LED) have proved to be just as efficient as lasers in promoting photobiomodulation (PBM)[2].

Inexpensive and safe light-emitting diodes (LEDs) have supplanted the use of expensive lasers in many indications. The better tissue penetration properties of NIR light, together with its good efficacy, has made it the most popular wavelength range overall[3]. In addition, LEDs provide safety in use: "In recent years, noncoherent light sources such as light-emitting diodes (LEDs) and broad-band lamps have become common. Advantages of LEDs include no laser safety considerations, ease of home use, ability to irradiate a large area of tissue at once, possibility of wearable devices, and much lower cost per mW. LED photobiomodulation is here to stay"[4].

Unlike high powered medical lasers, PBM does not employ a thermal mechanism, but rather a photochemical effect comparable to photosynthesis in plants where the light is absorbed and causes a chemical change.

The phenomenon was first published by Endre Mester at Semmelweis University, Budapest, Hungary in 1967 a few years after the first working laser was invented (Mester et al. 1967). Mester conducted an experiment to test if laser radiation might cause cancer in mice. He shaved the hair off their backs, divided them into two groups and irradiated one group with a low powered ruby laser (694-nm). The treatment group did not get cancer and to his surprise, the hair grew back more quickly than the untreated group. He called this "Laser Biostimulation".

Mechanism of Action

PBM has a wide range of effects at the molecular, cellular, and tissue levels. Molecular and cellular changes further initiate chain-effects on the body locally and systemically and with the right dosing act as an ignition for healing.

To define how PBM works, first we need to understand the concept of the "optical window", which is the spectrum of light with the most effective light penetration into the tissue. This optical window runs from approximately 650 nm to 1200 nm. Use of PBM in animals and patients almost exclusively involves red and near-infrared light within the range of 600–1100-nm, where light in the red (R) 635-700nm and near infrared (NIR) 760-1100nm regions has been studied extensively[5]. Water strongly absorbs infrared light at wavelengths greater than 1100-nm.

This range of wavelengths in the red and NIR range are frequently known collectively as 'red light', and the therapy that utilizes these wavelengths is known as Red Light Therapy (RLT) and will be referred to as such in this document. FlexBeam operates within a range of 625~635nm in red and 800~830 nm in near infrared spectrum, corresponding to primary absorption of photons of light in the IV complex of the respiratory chain, by a photoacceptor Cytochrome C oxidase (CCO).

In such cases, mechanisms are primarily nonthermal, involving endogenous chromophores eliciting photophysical (linear and nonlinear effects) and photochemical events at various length scales, resulting in beneficial photobiological responses.

Mitochondrial membrane has 'light receptors' chromophores responsible for photobiomodulation include:

- cytochrome c oxidase (CCO) in mitochondria
- NHDA
- light gated ion channels
- opsins
- flavins, flavoproteins
- intracellular water

The leading hypothesis of Photobiomodulation is that the photons dissociate inhibitory nitric oxide from CCO enzyme, leading to an increase in electron transport, mitochondrial membrane potential and ATP production.

Nitric Oxide has a vasodilation property and stimulation of microcirculation. Red light energy is absorbed by these receptors, increasing electron transfer across the mitochondrial membrane via a cascade of reactions, resulting in increased charge, which leads to more available energy all through the body. Another hypothesis concerns light sensitive ion channels that can be activated allowing calcium to enter the cell. After the initial photon absorption events, numerous signalling pathways are activated via reactive oxygen species, cyclic AMP, NO and Ca2+, leading to activation of transcription factors.

These transcription factors can lead to increased expression of genes related to protein synthesis, cell migration and proliferation, anti-inflammatory signalling, anti-apoptotic proteins, and antioxidant enzymes. Stem cells and progenitor cells appear to be particularly susceptible to PBM.

Red light interaction optimizes the body on the cellular and tissue level, however, each cell responds to this light-interaction differently, resulting in a diversity in the biomedical effects. Latest research suggests that Melatonin is a potential mediator of red light's therapeutic effects. Melatonin is a hormone that regulates circadian rhythm[6]. Melatonin is well recognized for its role as a potent antioxidant and is directly implicated in the free radical theory of aging. It has been shown to retard age-related increase in lipid peroxidation and oxidative damage. Research by Yeager et al. 2007 demonstrated, daily LED treatment increases enzyme activities of all three enzymes, SOD, GPx, and GRx, in the liver[7].

Zhao J. et al. demonstrated positive effects from red-light illumination and higher melatonin levels. Their results were in accordance with previously reported studies, showing that melatonin might be a principal component of red-light therapy[8].

Finally, we must mention, IR 800~830 nm is not only absorbed by CCO, but also absorbed at low levels by water. As Pollack et al. demonstrated that water exists as a more chemically/biologically active molecule, Shapiro et al. demonstrated that IR light could excite cells through water absorption, affecting the plasma membrane and altering the electrical capacitance, thereby depolarizing the target cells[9].

Since 1967 over 100 phase III (several thousands), randomized, double-blind, placebo-controlled, clinical trials (RCTs) have been published and supported by over 1,000 laboratory studies investigating the primary mechanisms and the cascade of secondary effects that contribute to a range of local tissue and systemic effects[10].

There have been a large number of both animal model and clinical studies that demonstrated highly beneficial PBM effects on a variety of diseases, injuries, and has been widely used in both chronic and acute conditions. Beneficial therapeutic outcomes including but not limited to the:

- alleviation of pain
- Inflammation
- Immunomodulation
- promotion of wound healing and tissue regeneration[11]
- stem cells generation as defined in Anders et al.

Research in Sports Medicine Applications

Muscle pre-conditioning

Recently, low-level laser (light) therapy (LLLT) has been used to improve muscle performance. Ferraresi et al. (2015) produced a randomized double-blind placebo-controlled trial with a single elite runner to assess preconditioning using a cluster LED immediately prior to the performance.

The best assessment parameters, such as kinetics of oxygen uptake (VO2), blood and urine markers of muscle damage (creatine kinase and alanine), fatigue (lactate) together with metabolic urinary parameters were used in the study, concluding LED therapy decreased blood and urine markers of muscle damage and fatigue (CK, alanine and lactate levels). The results suggest that a muscular pre-conditioning regimen using LED therapy before intense exercises could modulate metabolic and renal function to achieve better performance[12].

To evaluate the effectiveness of PBM for post-exercise recovery, Borsa et al. conducted a systematic review, analyzing elapsed time to fatigue, total number of repetitions to fatigue, total work performed, maximal voluntary isometric contraction (strength), electromyographic activity, and postexercise biomarker levels in total 12 randomized controlled trials with 32 data sets from 10 eligible studies, including active and sham options.

Exposing skeletal muscle to single-diode and multi-diode laser or multi-diode LED therapy was shown to positively affect physical performance by delaying the onset of fatigue, reducing the fatigue response, improving postexercise recovery, and protecting cells from exercise-induced damage[13].

Endurance and reduction of fatigue

Since muscle cells are exceptionally rich in mitochondria, this suggests that PBM should be highly

beneficial in muscle injuries due to the ability of light to stimulate stem cells and progenitor cells to help muscle repair.

Furthermore, the ability of PBM to reduce inflammation and lessen oxidative stress is also beneficial in cases of muscle fatigue and injury. Farresi et al. (2012) concluded in the literature review: athletes, people with injured muscles, and patients with Duchenne muscular dystrophy may all benefit[14].

A randomized double-blind crossover trial with placebo by a group of researchers from Brazil was performed to assess the use of similar parameters corresponding to Program 2 and 3 on FlexBeam (808nm, 100 mW, 4 J) on muscle fatigue resistance[1]. Use of active PBM device enabled to increase the number of maximum repetition (RM) to 52% ($p=0.002$). The results suggest using PBM promotes muscular fatigue resistance and should be applied during rest intervals, and after a series of intense exercises.

Ferraresi et al (2016) compiled an impressive review by searching 533 studies, of which 46 were included in the review (n=1045 participants) concluded:" there were more positive effects in favor of PBM than there are conflicting results or negative results. In addition, if all the positive results achieved in laboratory settings go on to demonstrate comparable improvements in sports performance in the real world, PBM will become very popular mainly amongst high level athletes".

Fatigue and DOMS

Antonialli et al. demonstrated that pre-exercise combination of super-pulsed laser and light-emitting diodes can significantly increase performance, decrease DOMS, and improve biochemical markers related to skeletal muscle damage[2]. Phototherapy increased ($p < 0.05$) MVC (maximum voluntary contraction that was compared to placebo from immediately after exercise and then to 96 h after exercise using 10 or 30 J doses (better results with 30 J dose). DOMS was significantly decreased compared to placebo ($p < 0.05$) with 30 J dose from 24 to 96 h after exercise, and with 50 J dose from immediately after to 96 h after exercise. CK (creatinine kinase) activity was significantly decreased ($p < 0.05$) compared to placebo with all phototherapy doses from 1 to 96 h after exercise (except for 50 J dose at 96 h)[15].

PBM therapy has a positive effect on maintenance of the effects from aerobic endurance training, but also minimizes loss of fitness during the detraining period. Thus, accelerating the return to their previous fitness levels[16].

LED specific study on muscle recovery after a damaging eccentric exercise by L.C. Borges et al. demonstrated, using 630nm (corresponding to Program 1 on FlexBEAM) in total energy density, 20.4 J/cm2 was effective in terms of attenuating the muscle soreness and muscle strength loss and ROM impairments compared to Placebo device[3].

Bone healing and Tendinopathies

Review by dePaiva et al. (2019) elicited 240 articles with 22 articles completely fulfilling the inclusion criteria. Wavelength used in PBM irradiation varied between 600 to 1000 nm with an energy density of 0.04-60 J/cm2. Low-energy density ranges appear to exert a biostimulatory effect on bone tissue, enhance osteoblast proliferation and differentiation on cell lines used in in vitro studies[17].

Tumilty et al. reported a case study demonstrating the feasibility of undertaking a randomized controlled trial of PBM for Achilles tendinopathy[18]. Naterstad et al. performed a study on rats concluding, PBM showed a significant superiority over commonly used anti-inflammatory pharmaceutical agents in acute collagenase-induced tendinitis[19]. Another study by Naeser et al.

demonstrated a "promising new, conservative treatment for mild/moderate Carpal Tunnel Syndrome cases"[20].

Pain and Inflammation Relief

PBM can reduce pain, inflammation in studies by Bjordal et al. 2006a, 2006b and swelling by Carati et al. 2003, caused by injuries, degenerative diseases or autoimmune diseases. Reduction of pain, reduction of inflammation in orthopedic and musculoskeletal conditions suggested by Aimbire et al. 2006, Gam, Thorsen, & Lonnberg, 1993. Basford et al. 1999 and Chow et al. 2006, demonstrated effectiveness for back and neck pain.

This interesting review by Chow et al. examines the evidence of neural inhibition as a mechanism underlying pain relief and anaesthetic effect of photobiomodulation (PBM). The electrophysiological studies examined neural responses to PBM in humans, animal models and cell culture. Evidence showed that PBM can inhibit nerve function in vivo, in situ, ex vivo, and in culture. Animal studies using noxious stimuli demonstrated nociceptor-specific inhibition with other studies providing direct evidence of local conduction block, inhibiting translation of pain centrally. PBM changes are reversible with no side effects or nerve damage. This review provides strong evidence in neuroscience identifying inhibition of neural function as a mechanism for the clinical application of PBM in pain and anaesthesia[21].

A review of the literature was performed to demonstrate the most current applicability of PBM for the treatment of skeletal muscle injuries, addressing different lasers, Further, review by Alves et al. elicited 17 of the 36 original articles on PBM and muscle injuries summarizing, the main effects of PBM were a reduction in the inflammatory process, the modulation of growth factors and myogenic regulatory factors, and increased angiogenesis. The studies demonstrated positive effects of PBM on the muscle repair process, which are dependent on irradiation and treatment parameters. The findings suggest that PBM is an excellent therapeutic resource for the treatment of skeletal muscle injuries in the short-term[22].

Conclusion

There is strong support in the literature for PBM/Red Light Therapy particularly relevant to the FlexBeam device. No evidence is found of adverse safety effects. "Obtaining pain relief from PBM might be a good alternative to the use of NSAIDs, because PBM has no reported side effects"[23].

FlexBeam is designed to use most researched, effective and safest wavelengths (red in 625~635nm and NIR 800~830nm), with the sufficient yet non-damaging power density of maximum of 50mW/cm^2 in red and 100mW/cm^2 in Infrared and at various dose from 70J/cm^2 to 83 J/cm^2, during the 10 minutes of pulsed at sweeping frequency between 1 – 1000Hz providing a sufficient stimulation with non-thermal effect. On average, charging with 4 J/cm^2 to 6 J/cm^2 per second.

FlexBeam has optimized Time/Dosage Algorithms for safe and effective stimulation. FlexBeam is equipped with the top quality Osram LEDs with optical lens adequately preventing extreme hotspots by spreading the light. These LEDs, delivering a precise range of wavelengths with less heat, but also considerably less toxic as they do not contain lead or any hazardous material[24].

FlexBeam

Product Design

- It is flexible to achieve targeted multi-angle delivery of light through its three modules to increase the area of irradiation.

- Three specific stimulation cycles (Program 1, 2, 3) that correspond to three levels of light penetration depth are helpful to target applications for the various cases.
- FlexBeam is equipped with both visible Red and Near-InfraRed wavelengths for the safest and most successful therapeutically wavelengths.
- Unique Recharge "Sunrise & Sunset" Power Profiles™ mimicking nature help to reach dose stimulation gently.
- Combination of Constant Wave and Complex Pulsed Frequency light stimulation is for maximum cellular responses.
- Innovative Recharge Wavelength Sweeping Functions are integrated into Complex Frequency Pulsed signalling.
- Optimized Time/Dosage Algorithms are safe and effective.
- Convenient Wrap-Around or Straight-Line application design choices in one device.
- Use on Battery or Plug-In Operations is convenient for practical ease of its use anytime, anywhere.

Contra-indications & Cautions

FlexBeam is not indicated to be placed:

- Over gravid uterus and breast tissue (possible neuroendocrine stimulation may occur)
- Malignancy (may increase metabolic activity of involved tissue)
- Over thyroid glands and testes
- Over the head a & face

CAUTIONS should be exercised in the following cases:

- FlexBeam should not be used over clothing. It may be used over bandaged wounds.
- Light sensitivity
- Do not use on children younger than 12 years and do not exceed 1/2 of the exposure time.
- Avoid use over black tattoos placement or change regime to Program 1 or 2.
- Never stare at the LEDs or use within 30cm of the eyes. Powerful invisible infrared light emitted.
- FlexBeam is not designed for use on the eyes, face or head area

For a full list refer to the IFU.

Use of FlexBeam

The device is placed at the area of complaint in skin contact. It can be fixed with the straps or just placed on the body. Simple operation in three steps. Once the FlexBeam is ON, the desired program is selected. Three Presets (1, 2 and 3) are automated in a cycle of 10 minutes. These programs are based on light penetration depth and to help the operator target the issue:

Target	Recommended program and cycle length
Skin	Program 1: 10 min/cycle (625~635nm red)
Small joints and stomach	Program 2: 10 min/cycle (625~635nm red and 800~830nm infrared)
Large joints and deep-seated muscles	Program 3: 10 min/cycle (800~830nm infrared)

1. Skin and Surface
Mostly red light for conditions that go skin deep.

2. Muscles and Tissue
Red/Infrared light at combined force for below the surface.

3. Deep Tissue and Joints
Powerful infrared light to penetrate deeper inside the body.

Once the device is set, it is simply placed on the part of the body where the issue is.

The device initiates the cycle promptly itself. Illustrated guide that comes with FlexBeam helps to decide where to place it. Once the cycle is complete, the operator can remove the device from the skin and if required, move it to the next part of the body to continue the session.

Guidelines

Wellness Applications:
Wellness Applications are the result of consolidation of literature search, users' feedback and clinical testing and designed to help the user to reach and maintain an optimal state of wellbeing. These applications typically target the abdomen and spine to achieve a general effect over the whole body. An average session lasts 20-30 minutes in total and consists of two, three 10-minute applications of FlexBeam.

Sports Applications:
FlexBeam is useful for preparing the body before exercise and for aiding recovery after exercise. FlexBeam can also assist with problems such as a recent shoulder injury or a bruised ankle supporting natural recovery for example. A typical session lasts 20-30 minutes in total and consists of 2 or 3 x 10-minute applications of FlexBeam in different places on the body.

Complex Applications:
If there are many issues in many places at once or they are combined with some general fatigue or sleep disturbance, or if no resolution with the simple approach can be achieved, extend the applications. For cases like this, it is best to do the sessions every other day for three or four weeks, rather than every day. Use a short break and then, restart again until you are satisfied with the results. Recommended applications of the FlexBeam are on the website: www.recharge.health/support

Disclaimer: Recharge makes no declaration about the safety or effectiveness of FlexBeam, and does not claim to diagnose, treat, cure, or prevent any disease. Use of the FlexBeam is not a substitute for a consultation with your healthcare provider. Information given should not be construed as medical advice.

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