

Application of Photobiomodulation Therapy in Acupuncture

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Abstract

Photobiomodulation (PBM) therapy is a therapeutic method that can produce a range of physiological effects in cells and tissues using certain wavelengths. The reparative benefits of PBM therapy include wound healing, bone regeneration, pain reduction, and the mitigation of inflammation. Advances in the development of laser instruments, including the use of high-intensity lasers in physiotherapy, have recently led to controllable photothermal and photomechanical treatments that enable therapeutic effects to be obtained without damaging tissue. The combination of PBM therapy with acupuncture may provide new perspectives for investigating the underlying therapeutic mechanisms of acupuncture and promote its widespread application.

INTRODUCTION

Stimulating specific acupoints during acupuncture can treat a variety of diseases.^[12] According to the World Health Organization, more than 40 disorders can benefit from acupuncture.^[23] Given the large number of treatments, the adverse events related to acupuncture are few; they include needle fracture, pneumothorax formation, spinal cord injury, and infectious diseases such as viral hepatitis.^[45] While the aversion that many people have to pain increases the difficulty of acupuncture being widely accepted as a treatment,^[67] interdisciplinary application of phototherapy in acupuncture may be a solution to acupuncture problems.

Phototherapy is a method of using light to treat and prevent diseases, and it has been widely used since ancient times.^[8] Research has shown that photobiomodulation (PBM) therapy using certain wavelengths can produce reparative effects in cells.^[910] Although other light sources for PBM are available, lasers are the most commonly used equipment in medicine and dentistry.^[11] Low-intensity laser therapy (LLLT), with an output power of 500 mW, has been widely studied. High-intensity lasers (class IV) have an output power of 500 mW or more.^[1213] In this article, we review the effects of PBM therapy in the context of combining it with acupuncture into an improved interdisciplinary treatment method.

MECHANISM OF PHOTOBIO-MODULATION

The effectiveness of PBM therapy depends on certain parameters, including the light source, wavelength, and energy density. Although other wavelengths, such as blue and green light (400–540 nm), are used in PBM therapy, red light or near-infrared light (NIR) (600–1100 nm) are the most commonly used wavelengths.^[14] One theory holds that the reaction between PBM and the target cells is a photochemical effect.^[15]

In mitochondria, the main chromophore that absorbs red light is cytochrome C oxidase. It is located at unit IV of the mitochondrial respiratory chain and affects the activity of various molecules, including nitric oxide, adenosine triphosphate, calcium ions (Ca^{2+}), and reactive oxygen species (ROS).^[1617] NIR light can increase the levels of ROS and cyclic AMP, interact with Ca^{2+} ,^[18] and activate transcription factors that affect cell differentiation, proliferation, and migration.^[19]

Although blue light can increase Ca^{2+} influx and phosphorylation of ERK1/2, skin exposure to ultraviolet irradiation also increases endogenous synthesis of Vitamin D, and most lasers use red or NIR wavelengths. Because hemoglobin and melanin have high absorption bands for light wavelengths <600 nm, superficial tissues are treated using wavelengths of 600–700 nm,

and deep tissues are treated using wavelengths of 700–1200 nm^[10] [Figure 1].

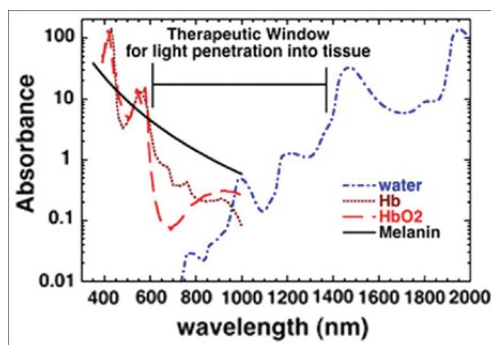


Figure 1:

Optical therapeutic window because of minimized absorption and scattering of light by the most important tissue chromophores in the near-infrared spectral region. Selected from Chung H, Dai T, Sharma S K, *et al.* The nuts bolts of low-level laser (light) therapy (J). *Annals of biomedical engineering*, 2012, 40(2):516-33

PBM therapy can also activate transforming growth factor-beta (TGF- β), an essential growth factor that increases wound healing. TGF- β can increase the expression of extracellular matrix (ECM) components, including collagen, and can inhibit matrix metalloproteinases, which affect the degradation of ECM components.^[151819]

Advances in laser technology have led to high-intensity laser therapy (HILT). In the mechanism of PBM, photomechanical effects are of concern,^[20] but HILT minimizes these effects. Compared with LLLT, HILT has the advantage of being high powered and weakly absorbed by superficial cell and tissue chromophores, resulting in a high penetrative ability that enables treatment of deep tissues and structures.^[21] HILT can affect the cytoskeletal organization in all cell types, including endothelial, mesenchymal, and connective tissue cells,^[22] which are involved in inflammation, pain, edema, and tissue repair.^[23]

Mechanical stress in the cellular environment is generated by both external and endogenous forces, and it can affect the behavior of all cell types by altering ECM mechanics, cytoskeletal organization, cell shape, and the nuclear scaffold.^[2425] Mechanotransduction, the process of transforming

external forces acting on cells into biological reactions, involves the ECM, integrin, Ca^{2+} channels, guanosine triphosphatase, adenylate cyclase, phospholipase C, and mitogen-activated protein kinase; all of these play important roles in the early signals triggered by mechanical stress. The cytoskeleton also plays a central role in mechanotransduction and coordinates multiple signal pathways.[²⁶²⁷]

Fibronectin is synthesized by various cells and is particularly important in ECM tissue. It can bind to collagen and the cell membrane, and it is involved in cell growth, differentiation, adhesion, and migration.[²⁸] Fibronectin also mediates cell adhesion and prevents cell migration. The effectiveness of HILT in controlling the production of ECM components and the arrangement of fibronectin molecules may be a consequence of tissue repair.[²⁹]

Recent studies have reported regenerative effects from HILT. It has been demonstrated to be effective in accelerating bone formation, inducing neochondrogenesis, and promoting cartilage matrix synthesis.[³⁰] In tendon and ligament injuries, HILT has been shown to improve the reparative process and antagonize possible fibrotic development.[³¹]

CLINICAL APPLICATION OF PHOTOBIOMODULATION THERAPY

PBM therapy has been widely used to treat joint and muscle diseases. It has been shown to be an efficacious treatment for the two most common types of arthritis: rheumatoid arthritis and osteoarthritis.[³²³³³⁴] PBM therapy can also improve athletic performance and training by reducing delayed-onset muscle soreness (DOMS) and ameliorating muscle damage after intense or long-term exercise. In addition, PBM therapy is used to treat muscle injuries caused by strain or trauma. Ferraresi *et al.*[³⁵] tested PBM treatment on the quadriceps femoris of a pair of twins; one twin received real PBM treatment and the other received a placebo treatment. The results showed that PBM treatment increased the maximum exercise load and reduced fatigue,

creatine kinase, and the Visual Analog Score (VAS) of DOMS. PBM therapy has also been shown to reduce interleukin-1 β and muscle atrophy (myostatin).[³⁶]

PBM is also an innovative therapy for neurological and psychological diseases. Studies have shown neuroprotective effects from PBM therapy in neurological diseases and psychological disorders that include traumatic brain injury (TBI), Alzheimer's disease (AD), Parkinson's disease (PD), depression, and anxiety.[³⁷] In human studies of neurological diseases, sleep quality, mood states, electroencephalogram patterns, and cognitive function have shown significant improvement after PBM therapy.[³⁸³⁹]

Spera *et al.* delivered laser treatment through an arterial catheter leading into the brain and found that the laser reduced the score for dementia in AD patients.[⁴⁰] In the only study of patients with PD, which was noncontrolled and nonrandomized, motor and cognitive functions improved after PBM treatment.[⁴¹] In patients with TBI, NIR laser treatment significantly decreased the signs of headache and improved sleep quality and cognitive and mood states. Henderson and Morries found that PBM therapy improved alertness and awareness in TBI patients with consciousness disorders.[⁴²] The first study on patients with major depressive disorder showed that transcranial PBM treatment could alleviate the symptoms of depression and anxiety in postirradiation patients.[⁴³]

PBM therapies, using lasers and light-emitting diodes, are widely applied in clinical dentistry and have been shown to improve a patient's dental health care and quality of life.[⁴⁴⁴⁵] Among dermatological therapies, PBM therapy has been demonstrated to be effective in diseases that include skin rejuvenation,[⁴⁶] hair-loss treatment,[⁴⁷] wrinkles, and skin laxity.[⁴⁸⁴⁹]

Laser acupuncture is a noninvasive technique that uses lasers to stimulate acupoints.[³⁴] Laser acupuncture can be used to reduce acute and chronic pain, induce recovery of damaged nerves, enhance peripheral circulation and metabolism, and reduce joint inflammation.[³³] The acupoints PC2

(Tianquan) and LU5 (Chize) can be irradiated to treat delayed muscle soreness (DOMS),^[50] and the acupoints and ST-35 (Dubi) and Ashi point (tender point) can be irradiated to treat knee osteoarthritis [Figure 2].^[51] In addition, Oates *et al.*^[52] found that laser acupuncture reduced pain during pediatric percutaneous kidney biopsy procedures. They used a semiconductor laser to irradiate acupoints GB25 (Jingmen), BL21 (Weishu), BL22 (Sanjiaoshu), BL23 (Shenshu), and BL52 (Zhishi) [Figure 3].

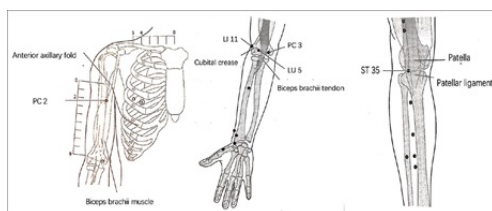


Figure 2:

Acupoint PC 2 (Tianquan), LU 5 (Chize) and ST 35 (Dubi)

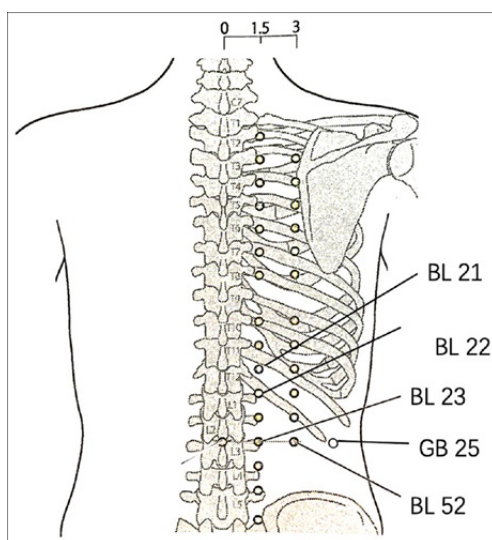


Figure 3:

Acupoint BL21 (Weishu), BL22 (Sanjiaoshu), BL23 (Shenshu), BL52 (Zhishi), and GB25 (Jingmen)

Vanzini and Gallamini^[53] performed ultralow laser therapy by irradiating acupoints LI1 (Shangyang), LI4 (Hegu), LI7 (Wenliu), LI20 (Yingxiang), LI20 (Yingxiang), and some acupoints around the eyes, including BL1 (Jingming) and ST1 (Chengqi). They found that the laser acupuncture reduced blood-flow anomalies in the central artery of the retina in patients with open-angle glaucoma [Figure 4]. Lv *et al.*^[54] used laser acupuncture to irradiate 13 ghost acupoints. After laser stimulation, functional magnetic resonance

imaging revealed decreased regional homogeneity/amplitude of low frequency fluctuation values in certain areas of the brain [Figure 5].

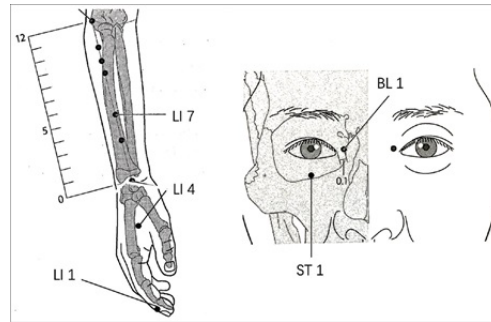


Figure 4:

Acupoint LI1 (Shangyang), LI4 (Hegu), LI7 (Wenliu), LI20 (Yingxiang), LI20 (Yingxiang), and some acupoints around eyes such as BL1 (Jingming) and ST1 (Chengqi)



Figure 5:

The 13 ghost acupoints. Selected from Lv J, *et al.* The brain effects of laser acupuncture at 13 ghost acupoints in healthy individuals: A resting-state functional MRI investigation (J). *Computerized Medical Imaging and Graphics*, 2016, 54: 48-54

Laser acupuncture has also been used for the treatment of diseases such as dry eye,^[55] postoperative nausea,^[56] and diabetic peripheral neuropathy.^[57] Moreover, laser irradiation of certain auricular acupoints and the neck ameliorated depression and alcohol-withdrawal symptoms in patients with alcohol addiction.^[58]

In recent years, the clinical applications of HILT have increased. In particular, HILT has demonstrated versatility and efficacy in the treatment of different musculoskeletal diseases, and it is considered to have anti-inflammatory, anti-edema, and analgesic effects.^[5960]

Sigman *et al.*^[61] reported the first case of PBM therapy in a patient with COVID-19. All evaluation criteria improved after the patient was treated four times, including the Pneumonia Severity Index and the SMART-COP score. The laser field was focused on the medial border of the scapula, which is

part of acupoints such as BL-13 (Fei Shu) [Figure 6].

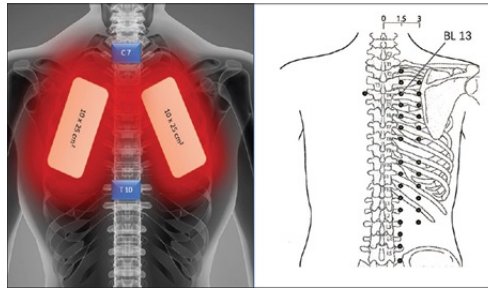


Figure 6:

The orientation of the PBM treatment for patient with severe COVID-19 and the location of BL 13 (Feishu). Selected from Sigman SA, *et al.* A 57-year-old African American man with severe COVID-19 pneumonia who responded to supportive photobiomodulation therapy (PBMT): first use of PBMT in COVID-19(J). *The American Journal of Case Reports*, 2020,21:e926779-1

INTERDISCIPLINARY OF PBM AND ACUPUNCTURE

Interdisciplinary research on PBM therapy and acupuncture, such as laser acupuncture, is documented. Laser acupuncture can treat a variety of diseases, but it has not been widely used in clinical practice.^[626364] This may be because laser treatment is relatively time consuming. Recently developed laser therapies, especially HILT, have several potential advantages compared with acupuncture and laser acupuncture treatment: (1) complications such as needle fractures, infections, or burns did not occur during PBM treatment, although bleeding at the acupuncture site, dizziness, pneumothorax formation, and artery and nerve damage were reported. (2) The parameters of the laser equipment are acceptable in clinical research and animal experiments. (3) Since noninvasive PBM treatment does not cause pain, fear, or tissue damage, it is more easily accepted, especially by pediatric and geriatric patients. (4) PBM treatment is easy, and HILT does not require much time.

CONCLUSION

Interdisciplinary research on PBM therapy shows that it has the potential for improving the clinical outcomes and elucidating the therapeutic mechanisms

of acupuncture, especially the effects of PBM at acupoints in high-intensity laser therapies. The combination of PBM with acupuncture could maximize both the reparative potential and the wider acceptance of acupuncture treatment methods.

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Conflicts of interest

There are no conflicts of interest.

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Keywords:

High-intensity laser therapy; interdisciplinary; laser acupuncture; low-intensity laser therapy; photobiomodulation

