Photobiomodulation: professional healthcare innovation or self-treatment?

An introduction to red light therapy for medical practitioners

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This document is a reflective analysis based on available literature and is not a systematic review.

This document was translated from Dutch into English with the assistance of AI and subsequently reviewed by the author. In case of any discrepancies, the original Dutch version shall prevail.

The document was originally written for the Dutch healthcare context. Healthcare systems, regulations, professional roles, and clinical practices may differ between countries. Therefore, certain statements or recommendations may not be directly applicable to other healthcare settings.

This document is intended for informational purposes only and does not constitute medical advice. If you have a medical condition and are considering using PBM, consult a physician before starting treatment, even if you intend to use PBM for a different condition or application.

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Summary

Photobiomodulation (PBM) is a form of therapy in which red and near-infrared light is used to influence biological processes in the body. Although a great deal of research has already been done on it, its application in regular healthcare is still very limited.

Meanwhile, more and more devices are becoming available on the consumer market for home use. As a result, consumers now have access to a treatment method that is often still unfamiliar to physicians and that physicians cannot simply apply. This raises questions about the role of practitioners, possible risks, and ethical issues.

The aim of this paper is to introduce physicians to PBM and to examine whether PBM should be seen as a professional healthcare innovation or as a form of self-treatment. To this end, attention is paid to, among other things, the technique, its possible applications, side effects, contraindications, and research.

PBM influences cellular processes, including mitochondrial energy production. There are indications of clinical effects for various conditions, but the quality and quantity of evidence differ greatly per application. Despite the large body of research (more than 7000 studies), the large-scale studies and standardized protocols needed for application in medical practice are still lacking.

Given the many positive studies, PBM deserves serious scientific attention. For PBM to be applied in medical practice, there is a particular need for coordinated research by specialty and condition, with agreed research methods and standardized reporting of treatment parameters. In addition, research is needed to determine whether safety guidelines or usage restrictions are necessary.

At the same time, self-application is expected to increase further, making it desirable for medical practitioners to have basic knowledge of the treatment method, as well as its possible applications and limitations within their field.

In addition, independent certification of equipment is needed, for both medical and consumer products.

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1. Introduction

Photobiomodulation[1] - hereafter abbreviated as PBM - is a form of therapy in which red and near-infrared light is used to influence biological processes. The light is delivered using lasers or LED light sources.[2]

Other names used for PBM include:

- Low level laser therapy (LLLT)
- Photomedicine
- Red light therapy

PBM was discovered in 1967 by the Hungarian physician and researcher Endre Mester while he was researching the effects of laser light on cancer in mouse models.[3] He then accidentally discovered that low-power laser light stimulated hair growth and wound healing in the treated skin.

Because lasers were very expensive at the time, the effects at the molecular level were unexplained, and the scientific community was skeptical, PBM remained unknown for a long time and was only applied to a limited extent. Only since the emergence of cheaper, safe devices and more systematic research has PBM started to gain more attention.

With the arrival of LED technology and the much lower cost of these devices, the consumer market now has a big head start on medical practice. Consumers have access to a form of therapy that can be applied to serious medical conditions such as dementia and Parkinson's disease, of which their doctors are often unaware or insufficiently informed. Consumers can buy the equipment through webshops, and can turn to various websites, YouTube, TikTok, and Facebook for information, scientific research, and treatment protocols. Although most information is available in English, the number of Dutch webshops, websites, and blogs is also growing.

In medical practice this is more complicated. A doctor cannot simply apply a treatment without sufficient evidence and guidelines. This raises the question of whether and when medical practice will be able to keep pace, or whether patients will increasingly take matters into their own hands to treat their own conditions, and whether the latter is desirable.

This document is intended to provide physicians with basic information and to pose the question of whether PBM should be a professional healthcare innovation or merely a form of self-treatment.

2. How does photobiomodulation work?

Photobiomodulation is usually described in the literature as a process in which light energy from red and near-infrared light is absorbed by cells, leading to various biological effects. The wavelengths used in PBM are part of the natural sunlight spectrum but are administered separately and in a targeted way.

Although research into the precise mechanisms of action of PBM is still ongoing, there are several effects that are consistently described in the scientific literature. One of the most consistently reported findings is that red and near-infrared light stimulates energy production by the mitochondria.

In the mitochondria, the powerhouses of the cell, the light is absorbed by cytochrome c oxidase, an enzyme in the electron transport chain. This leads to the temporary release of nitric oxide (NO), allowing oxygen to bind efficiently again and improving cellular respiration. The result is a higher production of adenosine triphosphate (ATP), the energy currency of the cell, giving cells more energy available for their tasks and repair.[4]

Another commonly described effect is that the release of nitric oxide can contribute to vasodilation, which can support blood flow to the tissue and in this way promote recovery processes.[4]

This process also produces low concentrations of Reactive Oxygen Species (ROS), reactive oxygen compounds, which are often also called 'free radicals'. At these low concentrations, ROS act as signaling molecules that activate cell communication and intracellular signaling pathways. Together with changes in ion currents, such as calcium, they can stimulate gene expression, protein synthesis, and the production of growth factors. As a result, exposing tissue to light can trigger a cascade of biological reactions that support the function and recovery of the tissue.[5]

The exact biological effects likely differ by wavelength of light, but it would go too far for this publication to describe all known or presumed cellular and molecular mechanisms of PBM. For more information, I refer to the review article 'Photobiomodulation: shining a light on depression' by Wang L. et al.[5] in which these processes are discussed in detail. The book 'The Ultimate Guide to Red Light Therapy' by Ari Whitten (2025) is also a good starting point.

3. Applications

PBM knows roughly four applications:

- Cosmetic
- Sports performance and recovery
- Medical
- Veterinary medicine

Cosmetic:
PBM can be used to counteract the effects of aging, such as fine lines and wrinkles, by stimulating collagen and elastin production. PBM can also be used for acne and hair loss.[6] Various devices using LED technology are sold on the consumer market for these applications, such as face masks, handheld devices, or small panels.

Sports performance and recovery:
In sports, PBM is used for better performance, endurance, and recovery.[7] For this, larger 'full body' panels with LED technology are usually used.
PBM is also used for faster recovery from sports injuries, such as muscle and tendon injuries. For this application, smaller LED panels or handheld devices are usually used for more targeted local treatment.

Medical:
In the medical field, PBM can be applied superficially, for example to support wound healing, but also to deeper tissues. PBM has also been studied for a wide range of conditions across virtually all specialisms, including diabetes, dementia, depression, Parkinson's disease, multiple sclerosis (MS), chronic pain, and osteoarthritis. [8]

These studies usually use lasers, but LED technology is increasingly being used as well.

Veterinary medicine:
In veterinary care, PBM is applied with lasers and LED technology for pain relief, promoting recovery, and the overall quality of life of pets and horses. For horses, for example, there are special pads for the legs and hooves.[9]

4. Systemic effects

Research has shown that PBM does not only act locally. There are indications that it also has systemic effects. For example, a 2014 study with rabbits found that when the right paw was illuminated, the left paw also healed faster after both paws had a screw implanted.[10] This effect is called the *abscopal effect*. Effects of 'remote PBM' have also been seen in rats with induced parkinsonism that were treated on the back while the head was shielded with aluminum foil.[11]

Systemic effects have also been observed in humans. In a 2024 study using an oral glucose tolerance test in healthy subjects, it was found, for example, that 15 minutes of PBM (670 nm, 40 mW/cm^2) on the back (800 cm^2) prior to the test significantly reduced the rise in blood glucose. This suggests that PBM can influence metabolism outside the directly illuminated area.[12]

In addition, several studies have shown that PBM, applied for other indications such as low back pain[13,14], can also have a positive effect on depressive complaints.

The systemic effects are thought to arise because PBM activates circulating factors, growth factors, and immune cells, which transmit signals throughout the body and thereby stimulate recovery and functional adaptation in untreated tissues. This is being further investigated by applying PBM intravenously, in which the light is delivered into the blood via optical fibers[15] ('intravascular laser irradiation of blood', abbreviated as ILIB).

One area that deserves special attention in this context is the abdominal area. Animal studies and small-scale human studies show that PBM applied to the abdomen can influence the gut-brain- axis, the communication between the gut and the brain, via interacting mitochondrial, immune, and microbial mechanisms.[16] A clinical study in people with Parkinson's disease reported that a 12-week PBM-treatment of the abdomen, head, and neck led to changes in the composition of the gut microbiome, including a shift in the ratio between the main bacterial groups (the Firmicutes:Bacteroidetes- ratio), which is often seen as a marker of gut health.[17] The original study into the effects of PBM showed significant effects on mobility, cognition, dynamic balance, and fine motor skills.[18]

5. Wavelengths and penetration depth

PBM makes use of lasers and LED technology.[19] The difference between the two does not lie in the wavelength, but mainly in coherence, beam density, and power.

Laser light is coherent and concentrates the energy into a narrow beam, allowing for higher power densities and sometimes slightly deeper penetration of the light. The power of therapeutic lasers is generally between 1 and 500 mW/cm^2, depending on the application and the device.

LED light is incoherent and spreads out more. It has lower power densities, often between 1 and 100 mW/cm^2, which is safer for use by consumers.

Both types of light sources can be effective, depending on the desired penetration depth and the size of the area to be treated.[20]

The wavelengths used generally range from 600 nm to 1100 nm. Both in scientific research and in commercial PBM equipment, the following wavelengths in particular are used:

- **Red light**: 630, 660, and 670 nm**.** These are mainly used for superficial applications such as skin improvement, stimulating collagen production, wound healing, and superficial pain relief.[21]
- **Near-infrared light (NIR)**: 810 nm, 830 nm, and 850 nm. These are usually applied for deeper applications such as muscles, tendons, nerves, and the brain.[21]
- **Higher NIR wavelengths**: 904 nm, 1064 nm, 1072 nm, and 1090 nm. These are also used for deeper tissues, such as muscles, nerves, and the brain.

Blue light is sometimes also used, with wavelengths between 405 and 470 nm.[22] This barely penetrates the skin but can be used for skin conditions such as acne because of its antibacterial and anti-inflammatory effects.

Red light and near-infrared light are not the same as the light used in infrared saunas. Saunas use far-infrared light (FIR) with wavelengths between 6000 and 14,000 nm. The effects of this, such as improved blood flow, are mainly based on the thermal (heat) effect.[23]

The actual penetration depth of red light and near-infrared light depends on various factors such as wavelength, power, distance to the skin, and tissue type. Diagrams often shown in the literature generally indicate that red light can penetrate about 4 to 5 mm below the skin surface and near-infrared light about 5 to 6 mm. [24] However, other sources suggest that the light can penetrate several centimeters into muscles and other tissues.[5] In practice, it is also noticeable that red light can be seen shining through a (small) hand or the cheek. The precise penetration depths therefore remain a subject of debate.

There is also uncertainty about the permeability of the skull. It is clear that both red light and near-infrared light can pass through the skull, but that a large part of the energy is lost in the process before the underlying tissue is reached. This partly depends on the site of administration and individual variation in skull bone thickness. Near-infrared light appears to penetrate bone better than red light, although red light is also used in research into brain treatment.[25]

6. Pulsing

Some lasers and LED devices deliver not only continuous light but also have one or more settings in which the light switches on and off very rapidly at a certain frequency, known as 'pulsing'.

According to a 2010 review study, there are indications that pulsed light can have different biological effects than continuous light, with frequency and other parameters also influencing the outcomes.[26] Since then, several studies have appeared comparing pulsed and continuous light, but the results have been mixed.

Due to the absence of a recent systematic review, it remains unclear for now whether pulsed light is more effective than continuous light.

7. Dosage

Besides power and wavelength, the dose of light is also important in PBM treatment. The dose (J/cm^2) is calculated by multiplying the power of the device (mW/cm^2) by the exposure time (seconds) and dividing the result by 1,000.[27] This figure indicates how much light energy is actually delivered to the treated tissue and is therefore important for achieving the intended therapeutic effect, without causing damage or providing insufficient stimulation.

Energy (J/cm^2) = Power (mW/cm^2) x Time (s) / 1000

The distance between the device and the skin plays an important role here. The power reaching the tissue decreases as the device is held further from the skin. How quickly the power decreases depends on the device's specifications, such as the light source and beam angle. The difference can be considerable between direct contact with the skin and a distance of a few centimeters.[28] When determining the correct dose, the recommendations and specifications of the device used should therefore always be taken into account.

It should be noted here that this calculation only gives the energy per cm^2 and does not take into account the total size of the illuminated surface. When treating larger areas, the total energy delivered can therefore be considerably higher than the value in J/cm^2 suggests. In the previously cited study using an oral glucose tolerance test (chapter 4), for example, an area of 800 cm^2 was illuminated. The energy here was 36 J/cm^2, which corresponded to a total delivered energy of 28,800 J.

This aspect is particularly relevant for the large LED panels available on the consumer market, with which large parts of the body can be illuminated in a single treatment. Although these devices are often evaluated based on the dose per cm^2, the total amount of energy delivered can increase considerably when used on large surfaces.

Because research shows that PBM does not work exclusively locally, but can also have systemic effects, the question arises whether energy per cm^2 alone is sufficient to fully describe the (degree of) biological response. The influence of the size of the treated surface therefore deserves further attention in future research.

8. The biphasic Effect

With PBM, the phenomenon known as the 'biphasic effect' must be taken into account. This means that the biological effects of the light do not increase linearly with the dose.

At too low a dose, PBM does not work; at higher doses, PBM can stimulate cells, but at too high a dose the effect can actually decrease or even become counterproductive.[29] Excessive exposure can lead to oxidative stress from too much ROS, causing cells to function less efficiently and slowing down recovery processes.

For this reason, consumer products often use a maximum exposure time of 20 minutes.[30,31] In practice, however, the biphasic effect appears to be less of an issue with these devices. There are anecdotal reports of people falling asleep during use and waking up pain-free after an hour. It may also vary by wavelength, tissue type, and other factors when this effect occurs. More research is therefore needed to better assess this effect.

9. Side effects and risks

PBM is generally described in the scientific literature as a safe and well-tolerated treatment when applied within standard therapeutic parameters.[32,33,34] When side effects do occur, they are usually mild and temporary and disappear spontaneously after stopping treatment. Reported reactions include temporary skin irritation or rash, fatigue, and mild headache.[35]

High-power consumer panels generally appear to be well tolerated by healthy individuals. In Facebook user groups, however, there are reports from people with complex conditions who say they need to limit use due to fatigue or other, not always clearly specified, complaints. Given the limited research into PBM in specific patient groups and the broad biological effects of PBM, caution - such as starting with a low dose - and appropriate medical supervision seem advisable for people with certain conditions, such as ME/CFS or Long COVID.

Although light therapy is successfully used therapeutically in ophthalmology[36], caution is warranted. It is well known that exposure to powerful light sources should be avoided. Laser light poses the greatest risk of retinal damage due to the strong concentration of the light. LED light is less concentrated and therefore less risky than laser light, but even so it is advised not to look directly into the light source, especially with powerful devices. Protective goggles are therefore often supplied with consumer devices.

10. Contraindications

The points of attention and possible contraindications below are based on what I encountered in the literature consulted and do not constitute an exhaustive overview.

There is currently no evidence that PBM causes cancer or stimulates tumor growth.[32,33,34] On the contrary, PBM is actually used in oncology to reduce the side effects of treatments, such as oral mucositis caused by chemotherapy and radiotherapy. Because experimental animal studies do not provide a consistent picture, caution and careful medical monitoring in tumors is nevertheless recommended.

Not enough is known about the use of PBM during pregnancy. Given the systemic effects of PBM and the fact that these have not yet been fully mapped out, caution during pregnancy seems advisable to me.

Diabetes is not considered a contraindication. Because PBM can affect blood sugar levels[12], I do consider it advisable in some cases to monitor blood glucose after treatment in patients with diabetes, especially when larger surface areas are treated (see chapter 7).

11. Research

More than 7,000 studies have now been carried out, including in vitro studies, animal studies, and human studies. These studies are tracked as comprehensively as possible in the database of Heiskanen: www.bitly.com/PBM-database.
Analysis of this database shows that research has been conducted within 24 different medical specialisms.

Specialisms in the Heiskanen database:

Cardiology and hematology	Gynecology and urology	Otorhinolaryngology
Dentistry	Infectious diseases	Pain medicine
Dermatology	Neurology	Plastic surgery
Emergency medicine	Neurosurgery	Psychiatry
Endocrinology	Oncology and supportive care	Pulmonology
Gastroenterology	Opththalmology	Rheumatology
General health	Oral and maxillofacial surgery	Sleep medicine
General surgery	Orthopedics	Veterinary medicine

Most of the research in this database was carried out in Brazil (1600+), followed by the United States (800+). China and Iran follow at a distance (together 400+). The Netherlands is among the countries where relatively little research has been conducted, with 26 studies as of 15 July 2026.

Although a great deal of research into PBM has now been done, this therapy is still little used in Dutch medical practice. A major problem is that the research is not coordinated: studies use widely varying wavelengths, devices, and treatment protocols, making it difficult to compare results and meaning that one study is not a replication of another. In addition, many publications do not report all parameters, such as wavelength, power of the laser or LED, dose, distance to the tissue, site of administration, treatment frequency, treatment interval, and follow-up. Even the name for the treatment is not consistent. Heiskanen's database contains a long list of names used in studies.

To improve this, Tunér and Jenkins[37] made proposals in 2016 to better report parameters, standardize research methods, and improve the reproducibility of studies. Unfortunately, these proposals have so far had little effect, and studies often remain insufficiently comparable and reproducible.

For many indications, randomized controlled trials (RCTs) are still lacking, which means the evidence base for PBM remains limited and the therapy cannot yet be included in guidelines. This is remarkable, given that existing research shows PBM can be a relatively cheap, safe, and promising treatment with many applications.

One possible explanation is that the technique itself cannot be patented. It is therefore not worthwhile for companies to invest a lot of money in independent research demonstrating the effect of their devices. As a result, they can only bring their products to market as 'wellness' products and not as medical products. However, some manufacturers have developed devices with specific components that can be patented, and have independent research conducted on these. This mainly concerns technology for treating the brain, probably because delivering light through the skull places higher demands on the equipment than treating other parts of the body, where tissues are more easily accessible.

12. Spotlight: PBM in neurology

For neurology, PBM is especially interesting because it is non-invasive and does not have the side effects often associated with medication. Because other parts of the body are relatively easy to reach with panels, flashlights, or lasers, I want to pay extra attention here to equipment currently on the market for application to the brain.

In several small studies, for example in traumatic brain injury, Alzheimer's, and Parkinson's disease, clinical effects have been measured on cognition, mood, sleep, and motor functioning, among other things. The neurophysiological effects of PBM are thought to include improved cerebral blood flow, modulation of neuroinflammation, reduction of neuronal apoptosis, stimulation of neurogenesis, increased production of neurotrophins, and promotion of meningeal lymphatic drainage.[5]

A large part of the research into the effects of PBM in neurological conditions has been carried out with lasers. It is often assumed that laser light can be aimed more precisely at specific brain regions. This can be important for conditions such as epilepsy, where stimulation of one area may be desirable, while influencing another, overactive area should be avoided as much as possible.

However, it is important to realize that light - including laser light - scatters in tissue, and that the skull also scatters the light.[38] The actual exposure in the brain may therefore be less sharply defined than the image of a narrow, perfectly aimed laser suggests. Moreover, as discussed earlier under 'Systemic effects', the effects of PBM are not limited solely to the directly illuminated tissue. As a result, effects may possibly also occur in non-illuminated parts of the brain.

Research is now also being conducted using LED technology. There are various companies that specialize in specific devices - usually so-called 'helmets' - designed to reach the brain relatively well. These companies seek collaboration with universities and healthcare institutions to test their products for various conditions. Examples include Vielight, Symbyx biome and SunpowerLED.

Vielight (Canada) has various helmets, both with and without their patented intranasal applicator, with which light therapy can reach the brain via the cribriform plate, the thinnest part of the skull. The helmets contain multiple LED modules that can be adjusted via an app for different applications.
Various studies have been published using Vielight's devices, focused on, among other things, Alzheimer's, Parkinson's, brain injury, Long COVID, cognitive enhancement, autism, and post-traumatic stress disorder. (See Vielight.com)

The helmet from Symbyx biome (Australia), the SYBMYX Neuro, also consists of LED modules spread across the skull to illuminate the brain. This helmet was tested in a small study in patients with Parkinson's disease. Effects were measured on facial expression, arm and leg motor function, gait, and tremors.[39] Further research is currently underway.
Symbyx biome also has another device, the PDCare. This is a laser with a CE marking and ARTG registration* for reducing Parkinson's symptoms. This device is applied to the abdomen and to the neck, just below the base of the skull.
**ARTG = Australian Register of Therapeutic Goods* (See Symbyxbiome.com)

SunpowerLED (USA) also has a helmet with LED modules. This proved effective in a small pilot study on the use of PBM for opioid cravings and depression during opioid withdrawal.[40] (See Sunpowerled.com)

Although, as far as I am aware, no studies have yet been published on the Neuronic (Germany) helmet, the device is technically interesting because, unlike the other helmets, it does not consist of separate modules but of 256 LEDs that cover almost the entire skull. These can be controlled separately by quadrant. (See: Neuronic.online)

13. Consumer market and PBM by prescription

Manufacturers may not simply bring a device to market as a medical device. As soon as medical claims are made, a product falls under the European Medical Device Regulation (MDR) and must meet strict requirements regarding safety and clinical evidence. This is why many red and near-infrared devices are sold as 'wellness' or lifestyle products. At the same time, sales sites present the underlying technology as 'scientifically proven', which can give the impression that this also applies to the equipment being offered.

There are now hundreds of this type of red light devices on the consumer market, such as:

- Small flashlights with or without a 'tip' for the nose, mouth, or ear
- Face masks
- Handheld devices for treating, for example, a joint
- Toothbrushes with red light in the head
- Caps for hair growth
- Mats or sleeping bags
- Small and large 'full body' panels
- Devices specifically for pets

If you search online shops for 'red light therapy', you come across the strangest products.

These devices often have multiple wavelengths: usually one to three in the red light spectrum and one to three in the near-infrared spectrum. Some devices also include blue light. The different wavelengths can generally be used separately or in combination. The power stated by the manufacturer is usually the sum of the power of the individual wavelengths.

The previously mentioned devices for treating the brain - which physicians may not simply work with - are also available for purchase by consumers. They can therefore experiment with them themselves. Although these expensive devices are not strictly necessary for this; the brain can be reached with any device with the right wavelength(s) and sufficient power, such as many handheld devices and panels.

In the United States, self-treatment is more embedded in the culture, but it stands to reason that the number of people in the Netherlands who take up PBM themselves will increase in the coming years under the influence of social media and influencers. In 2024, cosmetic physician David Mosmuller stated in the Dutch newspaper *Algemeen Dagblad* that he received daily questions from patients about the effects of PBM.[41] It is likely that this kind of question will increasingly be asked across more and more specialisms.

In the same article, dermatologist Gertruud Krekels advocates more research into the beneficial effects of red light on the skin, with the aim of gaining better insight into optimal dosage, wavelengths, and light sources, so that a genuinely effective home treatment becomes possible. This could lead to 'PBM on doctor's prescription'.

In addition to the lack of clear treatment protocols, there is another obstacle to advising or prescribing home treatment with PBM. Currently, manufacturers can make all kinds of claims, while consumers cannot verify whether the wavelength and power are actually accurate.

A research group from the UK, led by Dr. Mark Cronshaw, a dentist and expert in laser therapy and PBM within dentistry, has researched five LED flashlights for oral use.[42] These devices were purchased through webshops. Some were CE certified, but only for electrical safety, not as a medical device.

User feedback was generally positive regarding subjective pain relief and wound healing, but the results showed large differences in performance, inconsistencies in dosage, and limited evidence-based instructions.

The researchers concluded that home use of LED-PBM devices is potentially interesting, but that these devices cannot simply be prescribed to patients by professionals. Standardization, certification, and better instructions are needed to ensure safe and effective use.

14. Wellness treatments and alternative care

As long as no medical claims are made, PBM treatments can in principle be offered by commercial providers, such as wellness centers or gyms. The question, however, is whether this is desirable, because the biological effects of PBM extend far beyond those of, for example, an infrared sauna.

When someone purchases a device for personal use, they are themselves responsible for its use. But who ensures that sick people are not treated with non-certified equipment by people without medical training? Online, for example, I found a health center for alternative care that works without a doctor using a powerful PBM helmet (source: publicly available information).

15. Costs

Looking at the cost of PBM equipment, it can be a relatively cheap intervention. The devices currently available on the consumer market range in price from a few dozen euros to several thousand euros. It should be noted, however, that these devices were developed for individual use and may require adjustments - for example regarding hygiene - to be used in a clinical setting. In addition, medical certification is expected to lead to higher costs.

At the same time, PBM may be able to contribute to cost reduction in healthcare. In a small study (n=60; 30 PBM, 30 sham), for example, it was found that PBM can shorten ICU length of stay and improve muscle strength and mobility.[43] PBM can also be cost saving when used for wound healing in people with diabetes[44], potentially preventing amputations (in addition to the impact on the patient). There are also many other conceivable applications in which PBM could potentially be cost saving.

16. Discussion

It is well known that people need sunlight to produce vitamin D. Many people also know that sunlight affects the circadian rhythm and that a lack of sunlight can contribute to mood problems, such as seasonal depression. Much less well known, however, is that light also plays a role at the cellular level and can influence processes involved in energy production.

In modern society, many people spend most of their time indoors, often under artificial light, which limits exposure to natural sunlight. This raises the question of whether the reduction in exposure to natural light may have health effects that are not yet sufficiently understood.

At the same time, an increasing number of conditions - such as Parkinson's disease, Alzheimer's, and type 2 diabetes - are being linked to non-genetic mitochondrial dysfunction. This raises the question of whether there is a relationship between reduced exposure to natural light and disruptions in cellular energy processes. Such a link need not be causal, but could possibly be a cofactor, alongside other environmental and lifestyle factors.

Endre Mester's discovery in 1967 led to the emergence of a new field of research, with more publications appearing each month. Nevertheless, PBM is still only applied to a limited extent in medical practice, mainly due to the lack of large-scale randomized studies and, consequently, strong clinical evidence.

Meanwhile, a flourishing consumer market has emerged, with more and more devices for home use becoming available. These are promoted via social media, sometimes backed up by recent publications and interviews with neuroscientists.

Because PBM acts on biological processes in the body, this raises questions. When the technique is used to counter skin aging or to improve sports performance, this is unlikely to meet much objection. But when someone starts using it themselves to treat, for example, neurological conditions such as Parkinson's disease or the consequences of brain injury, they enter medical territory.

Because studies to date show that PBM has few side effects and that these are temporary, the risks seem limited. At the same time, there are other aspects that raise concerns.

If PBM develops further as a treatment method and is applied outside regular healthcare structures, the role of the doctor as assessor and guide of treatments changes. Meanwhile, medical involvement remains necessary for monitoring and possibly adjusting medication, for example when the application of PBM leads to a reduced need for medication in type 2 diabetes or Parkinson's disease.

There are also ethical questions at play. When someone chooses to treat themselves with a consumer product, the responsibility lies with that person. A different situation arises when someone applies PBM to another person, for example a family member with Parkinson's disease. In doing so, that person intervenes in the biological processes of the family member's body. Is that comparable to serving a meal, which also influences cell biology, or is it more comparable to administering medication or radiotherapy? And what about 'informed consent' in this case? The same applies to commercial application by people without medical training.

User groups on social media show that red light has a strong appeal for pets such as dogs and cats. There are even devices with separate settings for pets. Besides the question of whether this is desirable and ethically justifiable, this raises the question of whether the easy availability of PBM lowers the threshold for also exposing, for example, young children to red or near-infrared light. The perception that PBM is natural and harmless may play a role here. Parents might hope that their child will benefit from it, for example because small studies show that PBM can have a positive effect on cognitive functions. And what if parents start treating their child with autism, epilepsy, or another illness or condition themselves with it? Because there are no restrictions on the use of PBM, there is nothing to stop this.

The lack of large studies also carries a risk. Side effects of medication often only come to light once large groups of people start using it. This could also be the case with PBM. In addition, the studies that have been done are often only of short duration, so there is not yet insight into the long-term effects of PBM. This is relevant because there are consumers who use a panel with relatively high power for 20 minutes daily or several times a week (for example $90 mW/cm^2$).

From the perspective of the consumer, or in this case better described as the patient, it can nevertheless also be advantageous to have access to a (complementary) treatment method for one's own condition. This can contribute to greater personal control over one's health, making the patient less exclusively dependent on a healthcare provider. An additional advantage of home use is that the equipment is available at any desired moment, allowing the patient to determine the most favorable treatment time - for example before going to sleep - and frequency. The treatment can also be continued long-term if desired.

On the other hand, self-application of PBM is not automatically suitable for every patient. It requires sufficient knowledge of how it works, dosage, treatment duration, and possible limitations of the method. There are also not yet any clear, scientific treatment protocols to give patients guidance. As a result, there is a risk that patients apply PBM incorrectly or develop expectations that do not match current scientific understanding.[45]

17. Conclusions and recommendations

The question of whether photobiomodulation should mainly be seen as a professional healthcare innovation or as a form of self-treatment has no simple answer. Because of the head start of products on the consumer market, self-treatment of medical conditions is difficult to prevent, meaning doctors in practice may encounter people who apply PBM to themselves. To be able to respond to this, at least knowledge of the technique and its known biological effects is needed.

Because PBM has demonstrated biological effects, and research shows it also has clinical effects, it also deserves attention as a possible professional healthcare innovation, although the level of evidence differs by application.

To enable the potential integration of PBM into professional healthcare settings or its use as a prescribed treatment, coordinated research is required. Per medical specialism or per condition, RCTs should be carried out based on existing research, with agreements made on fixed parameters (for example the equipment, wavelength, and distance to the device) and on which parameters will be varied (treatment time, treatment frequency, or number of treatments). This is to prevent studies from being incomparable due to too many varying parameters. These parameters should be clearly stated in publications.

Research should also be conducted into possible side effects and long-term effects, so that it can be determined whether safety guidelines or usage restrictions are needed, such as a minimum age, a maximum treatment duration, or a maximum treatment frequency, for both medical and home use.

In addition, independent certification of equipment is needed, also for consumer products. This allows consumers and healthcare providers to trust that the technical specifications, such as wavelength and power, match what the manufacturer states.

Because self-treatment may possibly affect regular medical treatments, consumer products should carry the recommendation to always consult a doctor or other healthcare provider in the case of a medical condition.

18. About the author

Sandra Kouwenhoven has a nursing background and has been unable to work for a long time due to illness. During her search for relief from her health complaints, she came across PBM. While delving into this subject, she noticed a clear discrepancy between the rapidly growing availability of PBM equipment on the consumer market and its limited application and recognition within regular medical practice.

With this publication, she wants to help raise awareness of PBM among physicians and draw attention to the need for careful, coordinated, and standardized research. The aim of this is to strengthen the scientific evidence base, so that it can be better assessed which applications of PBM can genuinely find a place within healthcare and which applications are responsible and worthwhile as self-treatment.

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19. Disclaimer

This document is intended for information purposes only and does not constitute medical advice. If you have a medical condition and are considering using PBM, discuss this with a doctor first, even if you want to use PBM for a different complaint or application.

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