

# Digital Transformation of Photobiomodulation Therapy: A Step Forward to Become Mainstream?

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## Introduction

**P**HOTOBIMODULATION THERAPY (PBMT) IS SAFE, painless, efficient, cost-effective, and exceptionally well documented in the literature.<sup>1</sup> Notwithstanding the clear benefits, there are still some gaps in the scientific foundations of PBMT.<sup>2</sup> These gaps have led to some disappointing clinical studies, which in turn have adversely affected the marketing of PBMT to the general public as well as medical professionals.<sup>3</sup> Therefore, the impetus to fund groundbreaking PBMT research has suffered. If the PBMT community insists on working under the same *modus operandi*, this therapy will die before maturity.

## Mainstream Medical Therapy

The National Institute of Health (NIH) defines mainstream medical practice as a system in which medical doctors and other health care professionals (such as nurses, pharmacists, and therapists) have reached a consensus on the treatment of symptoms and diseases using drugs, radiation, or surgery.<sup>4</sup> Conventional medicine is what most practitioners use to treat patient conditions within a context of very specific scientific recommendations. Therapies must be tested and compared using the methodology of evidence-based medicine, and well-controlled clinical trials designed to confirm that the therapy is effective and safe. This approach is hierarchically organized according to the results acquired from rigorous clinical trials.<sup>5</sup>

## Scientific and Marketing Problems

To answer our question “why PBMT is not yet a mainstream treatment?” the usual answers from scientists and clinicians with experience of PBMT are related to scientific aspects, such as gaps in the complete understanding of action mechanisms, failure to translate results from animal experiments to human clinical trials, too few randomized blinded controlled trials, and an insufficient database of real-world evidence. Although these considerations are part of the answer, they are not the full explanation. Another relevant aspect is related to marketing aspects, such as prescription by medical professionals, reimbursement issues, and reliability of the therapeutic outcomes.

The root of the scientific issue is the characterization of the PBMT protocol using measurement of the external op-

tical irradiation parameters. These parameters are not the best route to predict the inner biological effects, and consequently the reproducibility of the therapeutic results.<sup>6</sup> Therefore, when the same external parameters are applied in different subjects, the biological stimulus is not the same. Therefore, even within the same experiment or clinical trial, the subjects are not necessarily subjected to the same biological stimulus. It would be more accurate to reproduce the “photonic stimulus” instead of the external irradiation parameters. The “photonic stimulus” is defined as the number of absorbed photons (considering their wavelength) at each part of the target tissue integrated over time. This quantity may be directly associated with the modulation of the intracellular molecular processes and changes at the tissue level. In this way, PBMT could be better standardized, more reproducible, more predictable, and importantly could be made independent of both operator and apparatus. How can this approach be implemented?

## Digital Transformational Technologies

Digital technologies have been the foundation of the fourth industrial revolution. A digital approach could be used to determine precise cause–effect correlations, caused by the photonic stimulus interacting with specific molecular processes, and allowing the personalization of irradiation parameters to deliver the same photonic stimulus to different individual subjects.

Computer simulation can be used to produce a “digital standard human,” which would be the most realistic and adaptable optical phantom to predict the photon fluence passing through the tissues during a human treatment session. The optimal dosimetry for each patient could be accurately determined from these simulations combined with personal biometric data acquired from wearable sensing devices, and other types of big data. The “internet of things” (IoT) in the context of PBMT allows the devices to interconnect and communicate with other medical devices. Eventually the data could be integrated with the entire infrastructure of health care services, hospitals, health insurance, and governmental authorities. This approach could help to find synergistic or antagonistic effects of PBMT when combined with other energy-based therapies, drugs, health supplements, exercise protocols, or additional procedures.

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The increasing use of global connections within the health care ecosystem fed by objective data from diagnosis and imaging is the basis for value-based health care. Artificial intelligence and machine learning algorithms could extract and analyze the vast amount of data generated during the delivery of PBMT to patients, wherever and whenever it takes place around the world. Since this digital technology can constantly learn from real-world use and experience, it has the capability to improve its own performance over time and increasing breadth of use.<sup>7</sup>

In recent years cloud computing, big data processing, and IoT technology has been applied in radiotherapy treatment planning.<sup>8</sup> Cloud computing could provide high-performance parallel processing for dose calculation of ionizing radiation using Monte Carlo code. Because Monte Carlo code can also solve the transport of visible photons in tissue, there would likely be considerable overlap between radiotherapy and PBMT applications.

Digital technologies have the potential to rejuvenate the field, since they will make PBMT more objective, predictable, and reliable. Consequently, the effectiveness of PBMT protocols to treat specific conditions will increase, regardless of the operator skills. Another important possibility is that the PBMT device could be automated to deliver the best personalized dose, thus removing the worrisome burden from the individual practitioner. Further, since the photonic stimulus is the quantity to be replicated, the design of the actual light source will not matter too much. Instead, what matters is only the device's ability to deliver the required photonic stimulus.

## Conclusions

Characterizing a PBMT protocol by the internal photonic stimulus instead of the external optical irradiation parameters is a paradigm shift. It is achievable using the fourth industrial revolution technologies. This digital transformation is a very important step to hasten PBMT becoming part of mainstream medicine. The characterization of PBMT dose by the internal photonic stimulus allows the replication of the same stimulus to patients with different phenotypes, different body regions, or even to different species. The marketing issues are helped due to the dissociation of the

therapeutic results from the particular medical device and its individual operator. It means that the therapy itself will move from a handcrafted unrefined protocol to a well-controlled, disease-customized, and patient-specific therapy. So, it will become possible for a doctor to prescribe a dose of PBMT and to predict its therapeutic results. Further, it will become realistic for practitioners to request condition-specific reimbursement, since the PBMT would be viewed as comparable with other approved therapies for specific diseases, symptoms, and/or conditions.

## References

1. Hamblin MR, Agrawal T, de Sousa M, eds. *Handbook of Low-Level Laser Therapy*. Boca Raton, FL: CRC Press, 2016.
2. Quirk BJ, Whelan HT. Near-infrared irradiation photobiomodulation: the need for basic science. *Photomed Laser Surg* 2011;29:143–144.
3. Hode L. What will it take? *Photomed Laser Surg* 2018;36:629–630. doi: 10.1089/pho.2018.4550.
4. Definition of conventional medicine. Available at: <https://www.cancer.gov/publications/dictionaries/cancer-terms/def/conventional-medicine> (Last accessed February 4, 2021).
5. Milano G. The hierarchy of the evidence-based medicine pyramid: classification beyond ranking. *Joints* 2015;3:101.
6. Björn LO. *Photobiology: The Science of Light and Life*. New York, NY: Springer, 2015.
7. Abdeldjalil K, Estrela VV, Borges Monteiro AC, França RP. Health 4.0: applications, management, technologies and review. *Med Technol J* 2018;2:262–276.
8. Chow JCL. Internet-based computer technology on radiotherapy. *Rep Pract Oncol Radiother* 2017;22:455–462.

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