Effect of Pulsing in Low-Level Light Therapy

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Background and Objective: Low level light (or laser) therapy (LLLT) is a rapidly growing modality used in physical therapy, chiropractic, sports medicine and increasingly in mainstream medicine. LLLT is used to increase wound healing and tissue regeneration, to relieve pain and inflammation, to prevent tissue death, to mitigate degeneration in many neurological indications. While some agreement has emerged on the best wavelengths of light and a range of acceptable dosages to be used (irradiance and fluence), there is no agreement on whether continuous wave or pulsed light is best and on what factors govern the pulse parameters to be chosen.
Study Design/Materials and Methods: The published peer-reviewed literature was reviewed between 1970 and 2010.
Results: The basic molecular and cellular mechanisms of LLLT are discussed. The type of pulsed light sources available and the parameters that govern their pulse structure are outlined. Studies that have compared continuous wave and pulsed light in both animals and patients are reviewed. Frequencies used in other pulsed modalities used in physical therapy and biomedicine are compared to those used in LLLT.
Conclusion: There is some evidence that pulsed light does have effects that are different from those of continuous wave light. However further work is needed to define these effects for different disease conditions and pulse structures. Lasers Surg. Med. 42:450–466, 2010.

Key words: low level light therapy; photobiomodulation; frequency; pulse duration; duty cycle; clinical trials

INTRODUCTION

Since the introduction of low-level laser (light) therapy in 1967, over two hundred randomized, double-blinded, and placebo-controlled phase III clinical trials have been published from over a dozen countries. Whereas there is some degree of consensus as to the best wavelengths of light and acceptable dosages to be used, there is no agreement on whether continuous wave (CW) or pulsed wave (PW) light is more suitable for the various applications of LLLT. This review will raise (but not necessarily answer) several questions. How does pulsed light differ from CW on the cellular and molecular level, and how is the outcome of LLLT affected? If pulsing is more efficacious, then at what pulse parameters is the optimal outcome achieved? In particular, what is the ideal pulse repetition rate or frequency to use?

PULSE PARAMETERS AND LIGHT SOURCES

There are five parameters that could be specified for pulsed light sources. The pulse width or duration or ON time (PD) and the pulse Interval or OFF time (PI) are measured in seconds. Pulse repetition rate or frequency (F) is measured in Hz. The duty cycle (DC) is a unitless fractional number or %. The peak power and average power are measured in Watts.

Pulse duration, pulse repetition rate, and duty cycle are related by the simple equation:

$$DC = F \times PD$$

Peak power is a measure of light intensity during the pulse duration, and related to the average power (measured in Watts) by:

$$\text{Average power} = \text{Peak power} \times F \times PD$$

Alternatively,

$$\text{Peak power} = \frac{\text{Average power}}{DC}$$

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