

Defining “The Specs” of Phototherapy Devices

By Douglas Johnson, ATC, EES, CLS

With phototherapy gaining popularity as a treatment modality, so does the amount of confusion surrounding the use of light as a physical agent. Not all light therapy devices are equal, and not all light is therapeutic.

Choosing the right phototherapy device not only dictates understanding the mechanism of how light interacts with biological tissue but the diverse set of parameters necessary to produce therapeutic effects. The photo-chemical effects of light in medicine are well known: blue light for the treatment of neonatal jaundice, the use of ultraviolet light to treat psoriasis, and visible light to treat seasonal affective disorder. The use of phototherapy devices as a mechanism to induce photo-chemical changes in injured tissues is an extension of these effects.

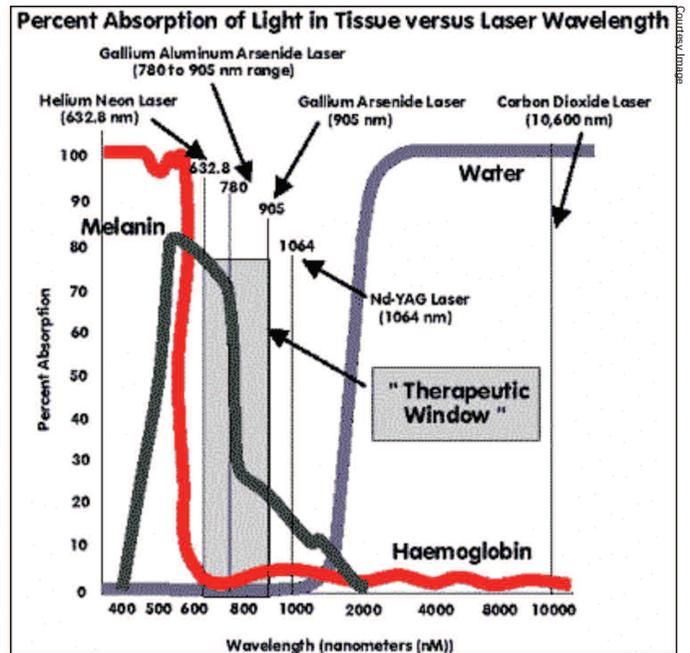
Though critics of phototherapy may continue to debate its overall effectiveness, the overwhelming scientific and clinical outcomes support the successful use of this new modality. It should no longer be a question of whether light has a biological effect on tissue but rather what are the optimal parameters for the successful uses of these light sources?

Experts agree the following five parameters define a phototherapy device: power and energy density, wavelength, diode construction, frequency and classification. Athletic trainers need a clear understanding of these technical aspects to effectively evaluate a light therapy device and prevent themselves from overpaying for a device that is nothing more than a flashlight.

power

The output of power will be by far the most talked about parameter. Sales representatives will continually discuss and debate the device’s power as if it were the sole factor of consideration. While the power is extremely important, its impact determines treatment time needed to deliver an adequate dosage at target. A laser with too low a power will have treatment times that are unrealistic; one with too high a power and the device may produce hazardous thermal effect in the tissue¹.

The primary effects of the phototherapy are based on photochemical changes not the result of thermal changes in tissue². However, light generation creates heat as a byproduct. This can continual build up of heat within target tissues can cut, vaporize and coagulate – this is the basis for laser as a surgical tool. Laser, like ultrasound, at low levels, can stimulate while at higher levels it becomes destructive.³



Mean output of power is most often measure of the devices power. However, peak power and energy density need to be taken into consideration in order to fully understand the device. Mean output of power (MOP) is the average power the device emits, this is important in devices that offer pulsing options. Peak power is a measure of the device’s maximum output and affects not only overall photon density, but also the absolute depth of the wave. Devices that have similar mean outputs of power may vary greatly on peak pulse powers.

The Super Pulsed (SP) laser, relatively new to the US, uses a Gallium Arsenide diode that can create extremely high pulse peak output power. When a laser is super pulsed, the laser light power varies between the pulse peak output power and zero. This pulse duration only lasts between 100 and 200 nanoseconds. The power density during these very high pulses is also very high, yielding an extremely powerful photon density with an increase probability of multi-photon effects.⁴ Biological tissue is “aware” of incident energy pulses only if they are over one millisecond in width. Pulses

of less than 1ns are less than the thermal coefficient of tissue relaxation, or put more simply, associated thermal effects are registered to the actual target site, and do not spread to surrounding tissue.⁵

Since probe diameters and spot sizes vary dramatically, power density, or the average power density, offers a true equivalent value for comparison. Defined by the equation Power Density = Energy/Area, this relationship is a far more comparative value.

wavelength

The “Therapeutic Window” contains all the wavelengths between 633nm (visible red) and 905 (infrared) that elicit biological responses. The light’s wavelength or color will determine the overall depth of penetration the beam will attain and is determined by the medium from which it is generated.

All biological tissue has specific absorption spectrum, so different wavelengths will stimulate different tissues and achieve different depths of penetration. Wavelengths in the lower end 633-780 nm of the window are more readily absorbed both hemoglobin and melanin therefore an increase in power will do nothing to improve its depth of penetration. These red phototherapy devices have a vast array of dermatological applications such as wound care and acne. Infrared photons from 780 nm to 905 nm are less likely to be absorbed in the skin and blood. These wavelengths will penetrate more deeply and are best suited for deeper tissue stimulation and musculoskeletal injuries.

Keep in mind, light from semiconductors is generally monochromatic. Since there is only the production of a single wavelength, this makes wavelength selection dependent of the specific depth of the target. So, it is of critical importance to choose a wavelength that will produce photons that are readily absorbed in the desired tissue. It is very evident why wavelength is the most crucial factor when purchasing a light therapy device.

diode construction

It is a common misconception that

“light is light”. If this were the case, there would be absolutely no need to purchase ANY phototherapy device, whether laser or not. Both sources of light can produce effects within the cells.

Cluster probes can contain any combination of laser, Infrared Emitting Diodes (IREDs), or Light Emitting Diodes (LEDs). Many instances, the type of diodes are not clearly stated by the manufacturer. As a matter of fact, a major laser company used a questionable ad campaign that basically led clinicians to believe they were selling a laser probe; when in fact, it was only a cluster of IREDs/LEDs. So be cautious! If you are unsure, ask whether the device uses laser, LED, or IRED diodes and in what combinations.

Manufacturers who only produce IRED or LED devices continually try to make the claim that non-coherent light sources produce equal if not better results than lasers. This is not been scientifically documented to be the case. Typically light and infrared emitting diodes can be produced at a fraction of the cost of their laser counterparts.

Furthermore, the vast majority of positive phototherapy research has been conducted using lasers – not LEDs. This can be attributed to the fact that LED and IRED technology is a relative newcomer to phototherapy. There is some research done by NASA using monochromatic LEDs that has shown

positive effects on various types of wound healing; however there studies have NOT support the use of monochromatic infrared (IRED) emitting diodes and their therapeutic benefit for pain relief.

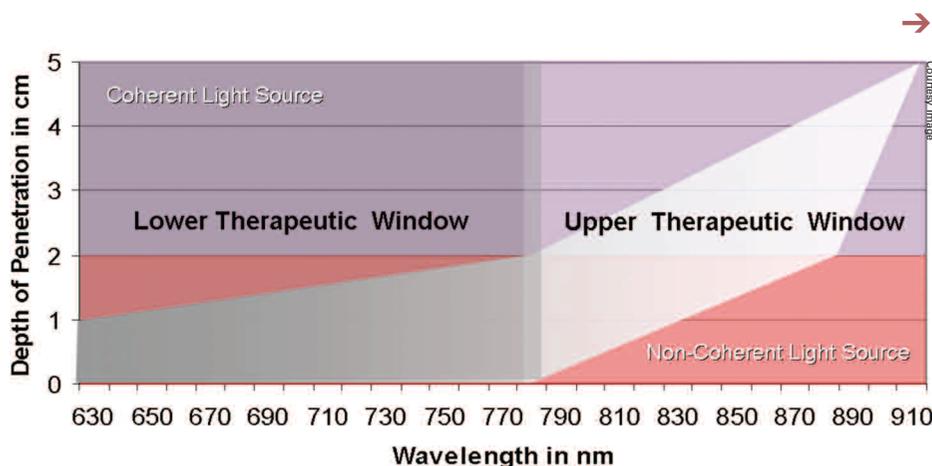
Many experts agree that the effect of laser and its property of coherence produce better therapeutic and clinical results.

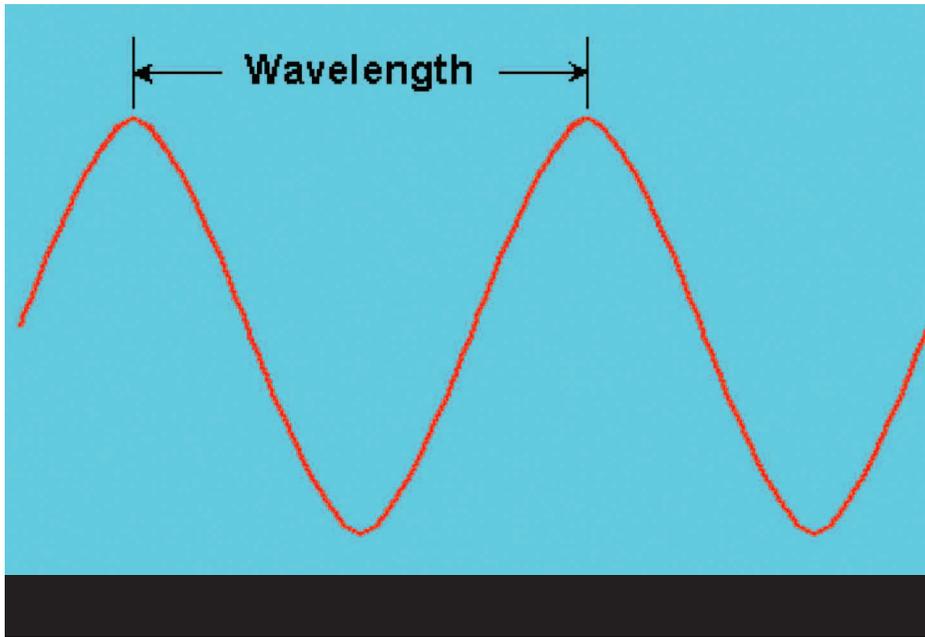
classification

Phototherapy treatments are generally considered safe and virtually without complications. ATCs should become familiar with any contraindications of use as well as any relative considerations necessary for safe operation of the device. Light generating devices are classified by their ability to cause damage to the retina and human tissue.

Class 1, 2 and 3a are regarded as safe. A class 3b laser is relatively safe, especially in the lower part of the class (MOP of 20mW or less) but this class includes lasers up to 500mW. It should be stated clearly that lasers in the far end of class IIIB and class IV have the potential for burns and other significant injuries.

Many of today’s continuous laser diodes offer a power range between 5 mW and 500 mW which is the upper limit of class 3b and between 8W and 100W with super pulsed diodes. There has been an alarming trend of late to increase power beyond this limit by





some manufactures. Continuous wave powers in excess of several watts have appeared and are considered class IV lasers. These class IV devices have power ranges from 500mw to a staggering 7500 mW Continuous making it a high power laser and extremely dangerous. The FDA has issued warnings with these devices about their safety and use: Class 4 lasers are hazardous to view under any condition (directly or diffusely scattered), and are a potential fire hazard and a skin hazard.

frequency

The light generated by phototherapy devices can be delivered in two ways: as a constant flow of energy (continuous-wave [CW] or super pulsed [SP] frequencies. The biological response to laser stimulation can be significantly different according to the frequency in which different wavelengths are applied, and even non-existent if two or more wavelengths are used simultaneously⁶.

A CW laser is generated by continuously pumping energy into the active medium to achieve equilibrium between the number of atoms raised to the excited state and the number of photons emitted. With this duration and with relatively constant power delivery to tissues, significant **thermal** damage occurs if there is significant

output of power (greater than 500mW). CW lasers may be modified to emit beams in a pulsatile fashion by adding electronically controlled, mechanically gated, timed shutters to interrupt the output beam at preset intervals. Therefore turning the beam on and off and decreasing its mean output of power. The higher the frequency, the more time the machine is switched off. This is "duty cycle".

Super pulsing lasers are always transmitted in a pulsing fashion. The output is determined by the frequency of the laser impulse. Each laser impulse produces exactly the same amount of energy. Unlike pulsed CW lasers, as the frequency of the laser increases, the mean output of power also will increase. SP lasers may also increase their MOPs by increasing the pulse duration of the laser.

By defining these five basic technical light therapy parameters, Athletic Trainers can evaluate the devices solely on there technical capabilities and not the surrounding hype. It is only then that the potential these devices can have on clinical outcomes is evident. **nn**

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