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Tendinopathy: The Role of Polarised Polychromatic Non-Coherent Light Commonly called Biopton Light

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Introduction

Low Power Laser Light (LPLL) is a commonly used light-therapy modality among physiotherapists for the management of common musculoskeletal disorders such as tendinopathies [1]. The effect of LPLL on wound healing has been investigated in many studies during the last two decades with conflicting results

[2]. Polarised polychromatic non-coherent light (Biopton light) is another form of light therapy that is commonly used to treat wound healing in dermatology and plastic surgery [3-5]. Manufacturers claim that Biopton light can be used in the treatment of common musculoskeletal disorders such as tendinopathies but experimental support is lacking [6-9].

Table 1 Manufacturer's explanation in the characteristic of polarized, polychromatic non-coherent light (Biopton light).

Polarisation
Its waves move on parallel planes. In this device polarization reaches a degree of approximately 95%, which narrows and concentrates the beam.
Polychromy
Polychromatic light contains a wide range of wavelengths, including visible light and a part of infrared range. The wavelength of this device's light ranges from 480 nm to 3400 nm. This electromagnetic spectrum does not contain ultraviolet radiation.
Incoherency
This device's light is incoherent or out of phase light. This means the light waves are not synchronized.

Available literature is predominately in the form of manufacturers pamphlets [10]. Polarisation seems to be the most important characteristic of Biopton light (**Table 1**) because

the Biopton light owes its proposed mode of action in this characteristic. LPLL and Biopton light differ in their characteristics of radiation (**Table 2**).

Table 2 Comparison of Biopton light with LPLL.

Polarized, polychromatic non-coherent light (Biopton light)	LPLL	Comments
Polychromatic light with a wide range of wavelengths (480 nm-3400 nm) using visible light and a part of infrared range	monochromatic light with single wavelength (632.8 nm or 904 nm the most common) using visible or infrared light	It is claimed that polarised polychromatic non-coherent light (Biopton light) with a longer wavelength has a greater penetration than LPLL
Incoherent or out of phase light	coherent or synchronised light	No difference in biostimulative effects. Phase of light is not the key factor in biostimulation
Truly polarized light	for practical purposes polarized light (Baxter)	Polarisation is the key factor in biostimulation (Kertesz; Fenyó). Polarised polychromatic non-coherent light

		(Biopton light) is a truly polarised light, while LPLL is polarised light for practical purposes. Thus, it is claimed that polarised polychromatic non-coherent light (Biopton light) have better biostimulative effects than LPLL
Energy density constant (2.4 J/cm ²)	Energy density ranges from 1 J/cm ² to 4 J/cm ² , but sometimes needing higher dosages up to 32 J/cm ² (Low and Reed, 2000). Energy density is calculated according to the condition	Optimal energy density is unknown. In polarised polychromatic non-coherent light (Biopton light) almost the mean rate of the range 0.5 J/cm ² and 4 J/cm ² is used, without needing calculation. However, we do not know if this is the optimal energy density
No specific user skills for handling	need specific user skills for handling and protective goggles	Polarised polychromatic non-coherent light (Biopton light) can be used by inexperienced therapists with this modality. Its usage is easy
No contraindications	Many contraindications such as, pregnancy, cancer, peacemaker, etc.	It is claimed that polarised polychromatic non-coherent light (Biopton light) can be used for all patients
Large diameter of the beam	small diameter of the beam	Polarised polychromatic non-coherent light (Biopton light) can radiate a large surface of the body
Expensive	Expensive	Polarised polychromatic non-coherent light (Biopton light) is less expensive than LPLL

Three devices are commercially available to deliver Biopton light: (i) the Biopton 2, (ii) the Biopton Pro and (iii) the Biopton Compact III [1]. According to the manufacturer's user guide, these three devices do not differ in output characteristics [11]. However, according to experts in dermatology plastic surgery [3-5] and physiotherapy [6-9], the Biopton 2 seems to be the most commonly used device in practice to deliver Biopton light.

Biopton 2 (**Figure 1**) is a product from Harrier Inc. USA and was developed in Switzerland. The emission of light may be administered in one-minute steps and controlled by an integrated soft-start/soft-stop electronic switch. When the treatment with Biopton 2 is over, there is a characteristic sound (beep tone). The output characteristics of Biopton 2, according to the manufacturers' user guide [10], are: light wavelength=480-3400 nm; degree of polarization=95%; specific power density=40 mW/cm²; energy density=2.4 J/cm². Biopton 2 is approved by the FDA (USA), TGA Australia, EEC and carries an ISO 9001 certificate and EN 46001 as a patented medically-approved product.



Figure 1 Biopton 2.

Manufacturer literature recommends that the Biopton 2 device should be used in practice as follows [10]: The probe of Biopton 2 is held at a 90° angle (perpendicular) 5-10 cm above the clean bare skin of the "injured" site as this is claimed to achieve maximal penetration of light. The regimen is six minutes of stimulation for at least three times per week for four weeks. Following this protocol, the Biopton light was found to be an effective treatment for patients with deep dermal burns [3, 4] and ulcers [5]. However, there are a few studies to find out the effectiveness of this protocol in common musculoskeletal injuries such as tendinopathies [6-9].

The manufacturer claims that there are no side effects for the use of Biopton light because there is no ultra-violet light in the Biopton spectrum so there is no tanning or heat effect on the skin [10]. No reports of adverse effects were found in conducted trials [3-9]. Manufacturers also claim that Biopton light is not harmful to the eyes, or to pregnant women or to patients with pacemakers [10]. No prophylactic measures for both, therapists and patients, were taken in conducted trials [3-9]. In addition, pregnant women and patients with pacemakers were not excluded from the trials [3-9]. Finally, the polarised polychromatic non-coherent light (Biopton light) cannot cause cancer because it is known that the dangerous wavelength of light is below 250 nm and the wavelength of Biopton light is outside of this range (480-3400 nm) [10]. The lack of side effects and contraindications of the Biopton light is supported by the conducted trials [3-9] and confirmed by the approval of the FDA (USA), TGA Australia, EEC, the ISO 9001 certificate and EN 46001 as a patented medically-approved product.

LPLL has a biostimulating effect [11]. Biostimulation is the reactivation of cell functions that allows regenerative processes to take place again [3]. This effect is directed to those cells that have been damaged or do not function efficiently any more [4]. A considerable amount of research has been performed to determine which of LPLL characteristics was the most important for the biostimulation effect [11-14]. Several different LPLL with varying monochromatic outputs were equally successful, showing that the wavelength played no role in the healing

effects [11, 12]. Coherent (in-phase) and incoherent (out of phase) light can cause the same biostimulative effects [14]. Polarisation appears to be the key factor in biostimulation [13, 15]. The Biopton light is a truly polarised light that could induce biostimulative effects in living cells similar to LPLL. The way that Biopton light obtains biostimulative effects is not known and is based on a variety of proposed mechanisms. Both parts, visible and infrared, of the electromagnetic spectrum of Biopton light, can explain these mechanisms. These lead to the same final photoresponse, but start the cascade of metabolic events at different cellular levels that assist tissue healing.

One proposed mechanism of action of biostimulation is the absorption of visible light energy by the mitochondria [16]. This may cause a chain of molecular events leading to an increase in cell energy and activation of nucleic acid synthesis, which is essential for tissue repair [2].

The second mechanism is obtained by the infrared portion of the light spectrum [2]. In a hypothetical physical model for biostimulation, the cell membrane was stated to be the site of stimulation [15]. In this hypothesis the Biopton light interacts with the polar heads of the lipid double layer of the cell membrane in which the biologically active proteins are incorporated. Due to the interaction with Biopton light, structural changes may occur to give the membrane a reordered distribution of the surface changes and to modify the lipid protein connections. This conformation change may influence the cellular processes connected with the cell membrane: receptor function, energy production, immune responses and enzyme reactions [15].

Different biological effects have been reported after polarised light radiation, including the stimulation of cell proliferation (especially in fibroblasts), the release of growth factors and the enhancement of collagen synthesis [13, 15, 17, 18]. It can be suggested that the tensile strength of tendons can be improved indirectly through the previously reported observations.

Another mechanism that might be responsible for Biopton light therapy's therapeutic effect is the local peripheral vasodilations, which improve blood flow and the delivery of oxygen to the soft tissue area, facilitating the transport of nutrients needed for soft tissue healing [2].

More research is needed to find out if the biopton light is an important factor in the management of tendinopathies.

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