Optimising Blue Light Phototherapy

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Background

Hyperbilirubinemia, or neonatal jaundice, caused by an accumulation of unconjugated bilirubin can be treated using Blue Light Phototherapy (1). At NHS Lothian, Medical Physics' limited involvement in the service includes annual equipment maintenance service. This MSc project included an investigation in to how Medical Physics might contribute to optimising the service, and standardising the approach to treatment via the needed development of dosimetry in Blue Light Phototherapy (2) as is already demonstrated in UV Phototherapy departments.

Method

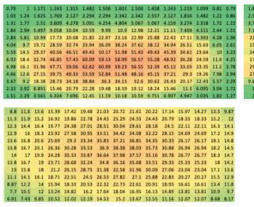
The efficacy and consistency of treatment devices were analysed, with respect to irradiance, spectrum, and surface area (3). 8 Dräger Phototherapy 4000 units and 3 GE Lullaby devices from the NNU, and new trial devices, a Dräger Bililux and a Löwenstein Biliblueleight were analysed. The irradiance for each device at differing heights were recorded using the appropriately matched broadband radiometers (4). The spectral irradiance was measured at 35cm using a spectroradiometer. The spatial distribution of light was measured over a grid of 5cm squares.

Results

Dräger 4000 units delivered low and inconsistent irradiances in comparison with the Lullaby LED units. The Bililux delivered the highest irradiance with the longest peak wavelength. The irradiance decreases as height increases between source and detector.

A

	Distance from Lamp to detector (cm)	Average Irradiance µW/cm^2/nm 30	35	40
Dräger 4000 (Fluorescent tubes)	Max	32.4	25.0	19.8
	Mean	24.9	20.2	16.7
	Min	14.9	11.2	9.8
Lullaby (LED)	Max	39.9	36.6	31.8
	Mean	39.2	34.4	31.1
	Min	38.8	32.9	30.0



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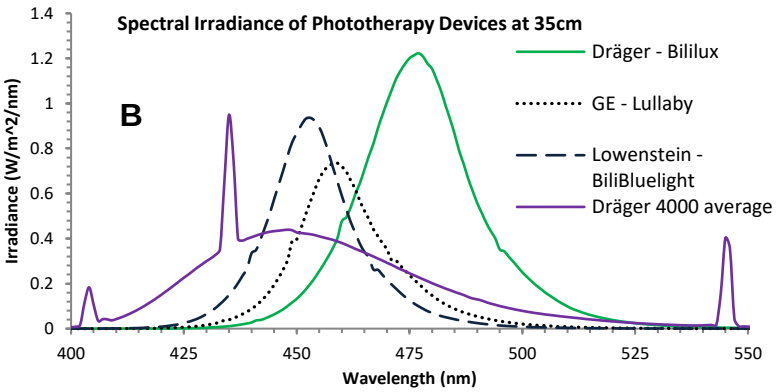

A: Irradiance results for Dräger 4000 and Lullaby units currently in NNU.
B: Spectral irradiance for all phototherapy devices
C: Normalised Spatial distribution of light for Lullaby (Top left), Billilux (Top Right and Dräger 4000 (Bottom Left)

Discussion

At treatment distances of 40-35cm, the Lullaby, Bililux and Biliblueleight delivered irradiances higher than 30 $\mu Wcm^{-2}nm^{-1}$, recommended by the AAP as intensive treatment (1), but the Dräger 4000 units did not. The Dräger 4000 units deliver inconsistent irradiance outputs. Devices with LEDs will deliver more consistent treatment to patients. The Bililux delivers a peak wavelength at 478nm, shown to be the most effective wavelength for reducing bilirubin levels (5), whilst also delivering the highest irradiances. In addition, the Bililux unit has an ergonomic and accurate treatment duration timer. Consistent irradiance values, standardised equipment set ups and accurate treatment times will allow for the calculation of dose to the patient. The development of dosimetry will mean that phototherapy can be prescribed appropriately.

Conclusion

The Bililux was recommended to replace the Dräger 4000 to deliver consistent high irradiance treatments at effective 478nm wavelength To develop dosimetry, irradiance and treatment times will be recorded and analysed in future work.

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Is there a need for optical radiation safety signage standardisation in the UK?

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Background

Laser radiation has the potential to cause adverse health effects to eyes and skin[1]. Exposure limit values (ELV) have been developed by International Commission on Non-Ionizing Radiation Protection based on current knowledge on damage thresholds, and the maximum levels of exposure to laser radiation which are not expected to cause adverse biological effects to the eyes and skin[2]. In the UK, the Control of Artificial Optical Radiation at Work Regulations[3] require areas where levels of artificial optical radiation (AOR) exceed the ELVs be demarcated, and that appropriate signs are provided in accordance with the Health and Safety (Signs and Signals) Regulations[4]. This signage plays a key role in alerting individuals to these hazards; however, no standardised signage exists. Across the Northern Ireland NHS Trusts, safety signage is audited by the Regional Medical Physics Service during routine laser surveys. This revealed a lack of standardisation between, and often within, departments. The aim of this work is to (1) review the laser safety signage across Northern Ireland, (2) compare this with signage from other modalities and national standards, and (3) decide if there is a need for standardisation.

Methods

1. Review key national and international guidance and legislation on safety signage applicable to AOR in a clinical environment
2. Discuss the signage used in MRI and radiation controlled areas with medical physics colleagues
3. Perform a retrospective review of laser room signage from our routine survey reports from laser healthcare sites across Northern Ireland

Results

We found a lack of consistency and many examples of signage containing information that was inaccurate, misleading, or did not adhere to UK standards[4,5]. There were cases of significant intradepartmental variation, incorrect information (e.g. laser wavelength on sign differed from wavelength of lasers in room), and language issues.

Conclusions

We recommend that a standard set of laser room signs be created and used that:

1. Follows the BS EN ISO 7010 pictograms and colour schemes[5]
2. Contains information on entry restrictions, hazards, and personal protective equipment (PPE) where appropriate.

Standardised signage would provide (1) clarity of information to staff and hospital users, (2) consistency across sites and services, and (3) enable the Laser Protection Adviser to use a uniform bank of resources to support departments.

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MedPen – AN LED BASED MED TESTER

Shijie Liang, Hannah Safi, Prawin Samraj, Donald Allan, Stuart Watson

Background. Narrowband UVB is the most common type of phototherapy used to treat skin diseases. "Narrowband" UVB refers to the 310nm-312nm wavelengths of ultraviolet (UV) radiation. To determine the correct dosage of UV radiation to give to a patient, it is good practice for the patient to be screened to establish a minimal erythema dose (MED). This is important to ensure a safe and efficacious initial dose that is administered to the patient [1]. A patient's MED can be estimated based on the Fitzpatrick skin phototype [2] which could be inaccurate. Another method is using a handheld device that utilises a light source giving a range of UV doses through metal filters [3]. However, it is widely known that existing handheld MED devices have poor stability, marked variation of output with lamp temperature [4, 5] and can be challenging to apply to a patient's skin due to large surface area of exposure. Currently, there is no method to carry out MED testing that is simultaneously accurate, fast and convenient. Therefore, this work aimed to design and develop a novel handheld MED tester, named MedPen which will address challenges with existing MED methodologies.

Methods. The components used to develop MedPen include a narrowband UVB LED light source, a flexible light guide, a UV sensor, an LCD touch screen and a microcontroller powered by a 9V battery. A range of UV doses were defined aligned to the local UVB phototherapy treatment protocol. A self-calibration feature was also incorporated into the design to ensure accurate doses are administered in each patient exposure.

Results. A comparison of the spectrums of the MedPen device, TL01 Dermalight MED handheld device and Waldmann UVB whole-body cabin are shown in Figure 1. Figure 2 shows the UV spectral irradiance plotted over a 4-minute exposure time which shows the stability of MedPen's intensity during an exposure and its reproducibility from test to test.

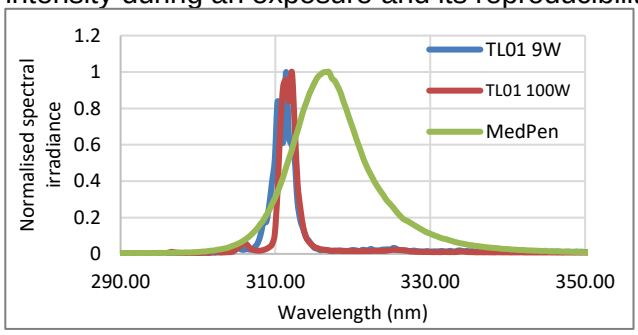

Figure 1

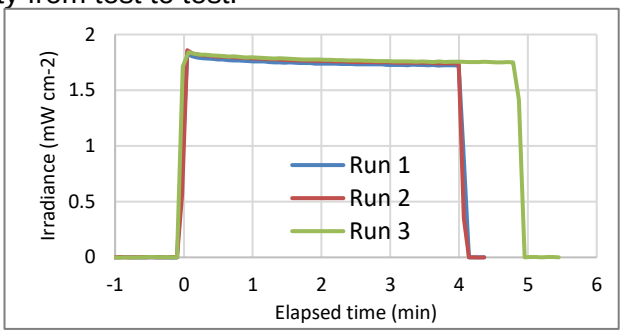

Figure 2

Discussion. The results show that the MedPen although producing stable results requires an LED that is able to give a higher output to reduce exposure time. Furthermore, the spectrum of the LED although close to that of TL01 is not ideal for this application. A suitable LED has been identified and future work will thus include replacing the current LED. An advantage of the MedPen design is that the LED prism light guide enables an easier application to the patient's skin. It allows for single small-area exposures thus avoiding skin blemishes and lesions.

Conclusion. The MedPen device developed in this work is advantageous as it eliminates many weaknesses in the established MED testing methods. These advantages include ease of use, accuracy and reproducibility. Future work includes the use of a high power 310nm LED.

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Lessons learned from preparation of IPEM report 115.

Michael Lynn and Colin Swift

The Artificial Optical Radiation Directive was transacted into UK law in 2010 as the Control of Artificial Optical Radiation at Work Regulations 2010. For the first time, regulation superseded guidance. The body which was then known as Public Health England (PHE) was contracted to produce a non-binding guide to explain to members of the European Community how to implement the requirements of the directive. This guide covered all aspects of how artificial optical radiation affected workers, including in the healthcare sector. A working party was formed by IPEM to consider only the impact on the healthcare sector. This working party produced a first draft of a report which was reviewed by IPEM referees. Further work continued to produce a useful document. An important part of the report was the provision of worked examples relevant to the healthcare sector.

The draft report emphasised that an inventory of non-trivial sources should be compiled. This begs the question “Who should do this?” At previous discussions and conferences, the suggestion was made that laser protection advisors (LPAs) were the obvious candidates. Neither the regulations nor the guidance have made any statement to this effect, but the editors of report 115 feel that it would be worthwhile for conference to debate this topic.

Photoprotection against Visible Light using New Formulation Sunscreen Products

Hannah Safi, Donna Parkin, Shijie Liang, Donald Allan, Stuart Watson

Background. Patients with photosensitive disorders (such as solar urticaria and erythropoietic porphyria) can sometimes be sensitive to visible radiation (1,2) . In the past the skin industry has neglected the effects of visible light on the skin and the formulation of products that shield the skin from visible light wavelengths (3). Dundee Cream was developed and is available on prescription for those with photosensitive conditions involving visible light (4). It does protect against visible light wavelengths; however, it is highly pigmented and may not be aesthetically pleasing. More recently, new formulation commercially available sunscreens have been developed incorporating compounds such as fractionated melanin (5) that offer protection against visible light wavelengths as well as UV. The aim of this study was to determine how effective these new sunscreen products are in blocking visible light. This was done by the measurement of visible light transmittance through a thin film of sunscreen sample spread on a transparent roughened substrate namely PMMA plates which simulate the porosity and texture of human skin.

Methods. 6 sunscreen products were tested. Uniform films of sunscreen were applied to PMMA plates before being mounted in a holder. The procedures related to the use of the PMMA plates, the application of the products and readings followed the concepts set out in standard ISO 24443:201226. An Asahi Spectra MAX-303 Compact Xenon Light Source was used to irradiate the PMMA plates. The visible light transmittance was measured using an Ocean Optics ST-VIS spectrometer.

Results. Figure 1 shows a plot of the intensity measured vs wavelength over the wavelength range 350nm-625nm for an uncoated plate and for sunscreen 1. The resulting transmission curve for sunscreen 1 is shown in Figure 2.

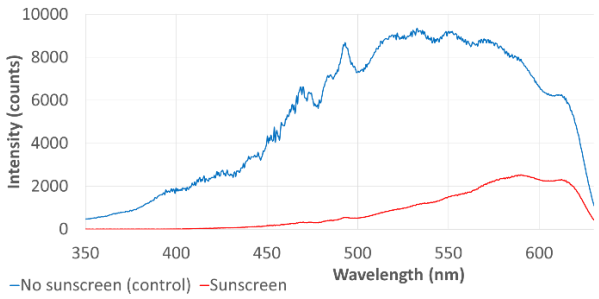

Figure 1

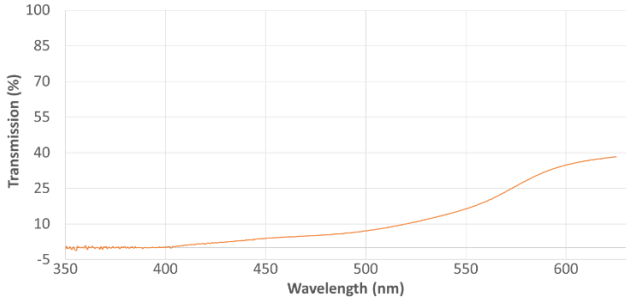

Figure 2

Discussion. The transmission spectra for one of the sunscreens tested showed a change in the mode of action at around the 400 nm region of the spectrum. The sunscreen samples show a sharp transition from strong blocking below 400 nm to increasing transmission in the visible range. However, there is still only a maximum transmission of 38% in the visible region of the spectrum, and that is at long wavelengths. The methods described in this work can be implemented for in-house testing of sunscreen products with relatively limited resources, this therefore results in the benefits reaching patients much sooner than awaiting the development of standardised testing of visible blocking by commercial laboratories

Conclusion. These preliminary results demonstrate that new formulation sunscreens provide protection for photosensitive patients in the visible light region of the spectrum.

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Development and assessment of a new phantom design for ultraviolet radiation phototherapy cabinet dosimetry calibration.

[1]Janus J, [1]Farley R, [1]Jade Clarke, [1]Chowdhury A
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Background. Consistent and accurate measurements for ultraviolet radiation phototherapy cabinet calibration are essential to ensure patient treatment safety and efficacy. Calibration and service checks should be carried out regularly to enable early detection of equipment faults and thus minimize potential risk to patients and staff [1]. Also, precise calibration measurements allow for effective and safe patient treatment dose, allowing possible transfer between phototherapy cabinets [2]. The direct and indirect methods are mainly used for measuring the irradiance inside of a cabinet for phototherapy dosimetry calibration [1, 2]. In the direct method, the assessor enters the cabin and takes body site measurements whilst the cabin is switched on. The assessor must wear the appropriate PPE and protect all exposed skin and eyes with the direct method. In the indirect method, a tripod is used to hold the detector and patient effects are corrected by multiplying by an occupation correction factor. Both the direct and indirect methods have limitations. We explore possible phototherapy phantom designs that could simulate the direct method of calibration measurements, avoiding the requirement of an assessor needing to remain in the phototherapy cabinet. Using a phantom inside the cabinet also minimises possible variabilities introduced by different size, shape and even possibly colour or material of the clothing of assessors.

Methods. We carried out a review of available literature on UV phototherapy phantoms that are used for cabin calibration measurements. We also conducted a survey of hospitals to determine what dosimetry calibration methods are currently used and preferred. Based on the information we gathered we produced a summary of possible phantom designs for phototherapy calibration measurements, exploring the advantages and disadvantages of each design. Based on the current information and our experiences from using the phantom we currently use, and from phototherapy staff on various patients' body shapes and heights, we show and compare recommended designs.

Results.

- There is a paucity of literature on UV phantoms used for dosimetry in phototherapy. Despite the indirect method as a favourable and recommended method [1, 2], many centres still use direct dosimetry measurements.
- We show preferred phantom design would be one that is lightweight, easy to transport, quick to assemble and allows precise and accurate reproducible measurements.
- The phantom should also be designed so that it is easy to attach the UV detectors to the surfaces. Current practice involves securing the detectors with tape, which is not very efficient.
- A problem often encountered clinically is that tall patients can block the sensors in the cabinet, affecting the treatment time. A phantom with an adjustable height would be useful to test the impact of patient size and limitations in different models of phototherapy cabinets.

Discussion. The irradiance measurement inside a phototherapy cabinet depends not only on lamp output but the person's position in the cabinet and the location of the UV meter within the cabinet. Good phantom design features should consider manufacturing cost, durability, transportability, ease of assembling the parts and setting up, irradiance measurement reproducibility.

Conclusion. Three phantom designs are presented including the main features, advantages and disadvantages.

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