Transmitted irradiance not as expected in enclosed handheld Minimal Erythemal Dose (MED) device

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Title Page

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Summary Statement

What's already known about this topic?

- The MED produced by a handheld semiautomated device produces a similar but lower MED than the traditional template test method.
- The ultraviolet B irradiance from a handheld MED device varies with internal temperature.

What does this study add?

- The internal temperature of the handheld MED device varies along the length of the lamp resulting in a non-uniform lamp irradiance.
- Non-uniform lamp irradiance results in transmitted irradiances that are different from claimed values.
- The claimed 1.26 dose progression can be used if the first and second aperture are disregarded.

Text:

Dear Sir / Madam

In 2014 Turner and Goulden demonstrated that the ultraviolet B (UVB) irradiance from a Handheld Minimal Erythema Dose (MED) device varied depending upon the internal temperature of the device[1]. The Handheld MED device in question consisted of a single PL-S 9W/01/2P narrowband UVB fluorescent lamp located inside a plastic handheld enclosure. On the treatment surface of the device there were 10 apertures, each one containing attenuating foil to deliver a range of doses for a fixed exposure time. The link between temperature and irradiance led the investigators to recommend a shorter warm-up time for the device than had been previously advised.

The transmitted irradiance from each aperture in a handheld MED device depends upon two variables – the transmission properties of the attenuating foil and the UV output from the section of lamp located directly below the aperture. Since fluorescent lamp output varies with temperature, the claimed transmitted irradiance through each window will only be valid if internal temperature is constant along the length of the tube.

In the Turner and Goulden study, the irradiance from a single (fully open) aperture was monitored and compared to the temperature from a single internal temperature probe. We sought to expand on the previous study and determine if internal temperature varied consistently at different points in a handheld MED device. We investigated the impact this would have on the narrowband UVB irradiance delivered to the patient.

Temperature of the MED device was monitored by two methods. An infrared camera (FLIR T420bx, FLIR, Portland, USA) was used to produce a thermal image of the ultraviolet lamp at multiple time points. Then three measurement points on the MED device were defined; Aperture 1 the base of the fluorescent tube corresponding to the fully open aperture, Aperture 3 the middle of the fluorescent tube corresponding to the aperture with a nominal transmission of 63% and Aperture 5 the tip of

the fluorescent tube corresponding to the aperture with a nominal transmission of 40%. These three points are represented quantitatively with a PicoLog USB TC-08 Thermocouple Data Logger for temperature and an IL1400A radiometer with UV SEL005 detector and TLST 7mm diffuser for irradiance. Measurements were made during the first ten minutes after the device was switched on with a subsequent ten minute switch off, repeated multiple times.

Thermal imaging and quantitative measurement showed that the base of the fluorescent tube, and in particular the area covered by aperture 1 (Figure 1a), reached a much higher temperature than the middle or the tip of the fluorescent tube (Figure 1a). Therefore the irradiance along the length of the fluorescent tube was not uniform, which in turn meant that the transmitted irradiance at the first and second aperture were lower than stated (Figure 2a).

In this instance, using the stated transmission results in an incorrectly low MED, potential under-treatment and increased phototherapy visits. Our findings are corroborated by our own experience (handheld MED tester results 57% of traditional MED template method) and a study by Lynch et al (handheld MED 67% of traditional method)[2].

However Figure 2b shows that if Apertures 1 and 2 are discarded the transmitted irradiances will follow the expected 1.26 progression. From our own experience, when we compensated for the measured transmitted irradiances, we found the handheld MED tester result to be 82% of the traditional MED template method. This agrees well with the 88% found by Otman et al[3].

Our study demonstrates a need for caution and independent dosimetry prior to the use of handheld MED devices. The devices can be used with the anticipated 1.26 dose progression if the first and second aperture are ignored.

References

1. Turner D,Goulden V. Determination of the optimum operating point for a handheld minimal erythema dose device. *Br J Dermatol* 2014; **170**: 996-97.
2. Lynch M, Carroll F, Kavanagh A., Honari, B. et al. Comparison of a semiautomated hand-held device to test minimal erythema dose before narrowband ultraviolet B phototherapy with the conventional method using matched doses. *J Eur Acad Dermatol Venereol* 2014; **28**:1696-1700.
3. Otman SGH, Edwards C, Gambles B. et al. Validation of a semiautomated method of minimal erythema dose testing for narrowband ultraviolet B phototherapy. *Br J Dermatol* 2006; **155**: 416-21.

Figure Legends

Figure 1 a) Thermal imaging of handheld MED device during its warm-up phase. Images were acquired at two minute intervals from two to ten minutes. After ten minutes patient testing would take place. White dots on the image at ten minutes indicate the location of each of the device apertures. The temperature at aperture 1 is higher than all other apertures, explaining the lower irradiance observed at this location. b) Quantitative results from thermopiles corroborating the information from thermal imaging.

Figure 2 a) Measured (dashed diamond) transmitted irradiance from each of the handheld MEDs ten apertures. Claimed (solid square) transmitted irradiance if the output was normalised to Aperture 10. This clearly shows the lower than expected irradiance at Aperture 1 and 2, which corresponds with the higher temperature shown in Figures 1a and b. b) If Apertures 1 and 2 are discarded and Aperture 3 is treated as the 100% aperture then the measured dose progression is similar to the claimed 1.26 dose progression.

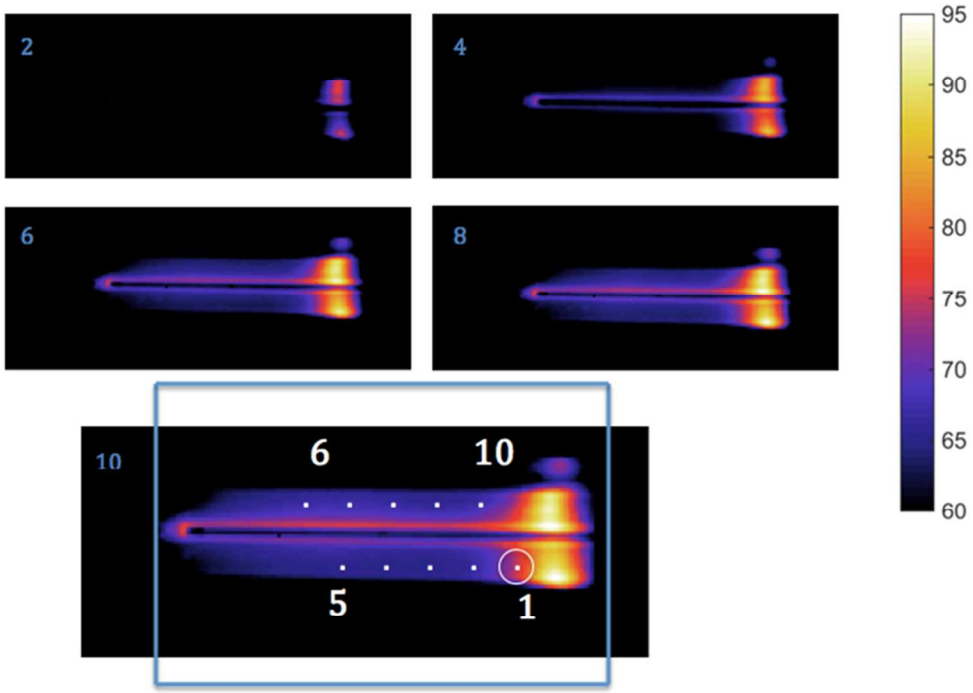

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Figure 1a
254x190mm (96 x 96 DPI)

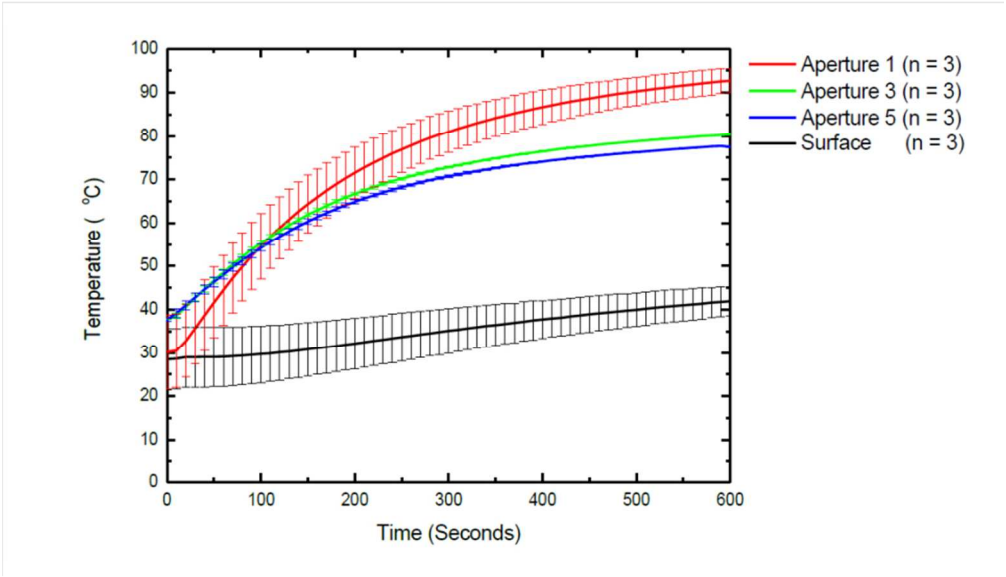

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Figure 1b
254x190mm (96 x 96 DPI)

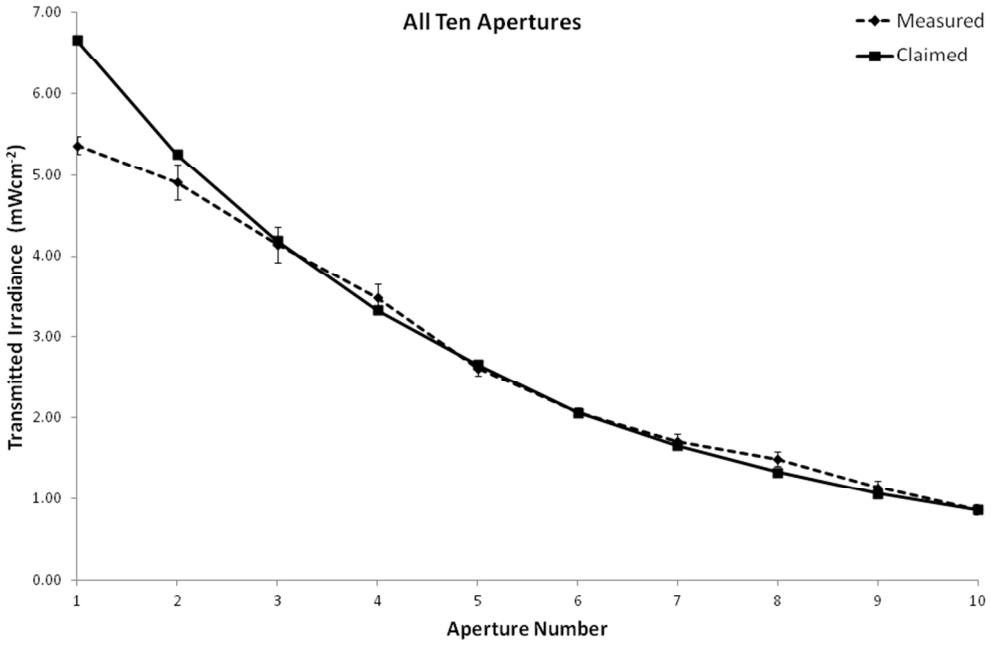

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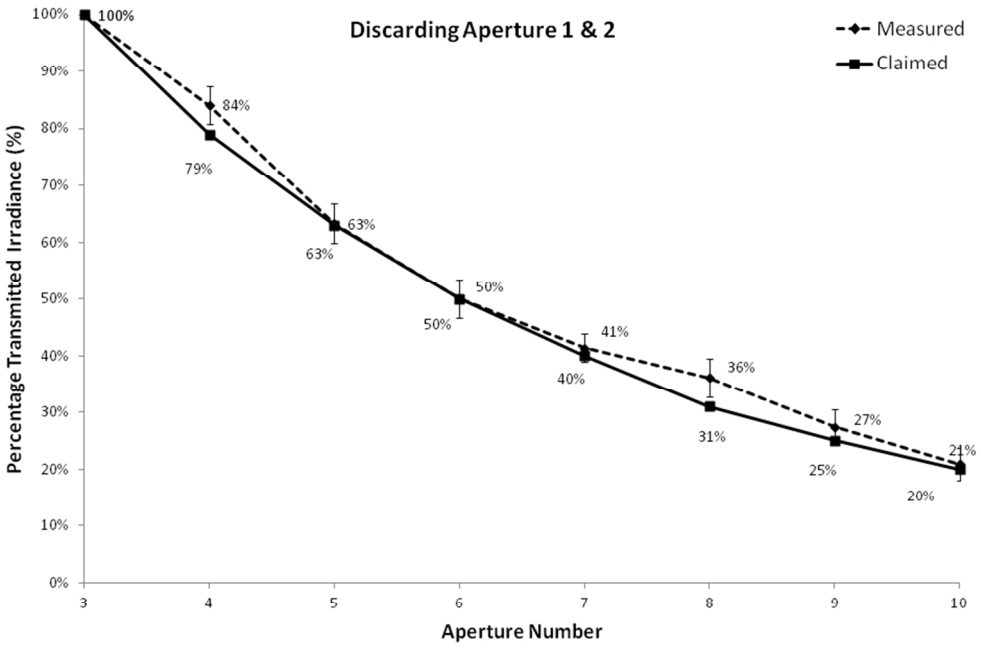
Figure 2a
254x190mm (96 x 96 DPI)



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