Vitamin D has important biological functions within the human body, such as bolstering skeletal health and lowering the chances of developing cancers and autoimmune diseases. However, an estimated 1 billion people globally are affected by vitamin D deficiency. Although humans can acquire some vitamin D from their diet, a large portion is produced cutaneously through exposure to sunlight. 7-dehydrocholesterol (7-DHC) in the skin absorbs ultraviolet B (UVB) radiation emitted by the sun and is converted to previtamin D₂. Through a heat-dependent process, previtamin D₂ transitions into its more thermodynamically stable isomer, vitamin D₂.

While vitamin D dietary supplements are widely available, those with fat malabsorption disorders or who have undergone gastric bypass surgery are most likely to suffer from vitamin D deficiency. In addition, worldwide, approximately 50% of the population is estimated to be vitamin D deficient. Worldwide, about 1 billion people are affected with vitamin D deficiency. In the United States, the prevalence of vitamin D deficiency in the population is estimated to be 40%.

Objective
The objective of this study is to determine whether the new LEDs are even more efficient than the prototype in the production of vitamin D₂.

Methods
With a solar radiometer (Solaracheck), each LED's output was measured in Minimal Erythemal Dose (MED: amount of UV radiation that causes a slight pinkness to the skin 24 hours after exposure) per hour from approximately 1 cm away.

Using Syrofoam holders with holes positioned over the LEDs, borosilicate ampoules containing 50µg of 7-DHC in 1 mL of methanol were placed directly over the LEDs and exposed to 3 MEDs (New LED: 17 min 36 sec, Prototype LED: 8 min 18 sec). After irradiation, 200µL of nitrogen and re-sonicated and incubated at 50°C water bath overnight. This was to convert the ampoules to vitamin D₂. For the ampoules and vitamin D₂ for the ampoules, the percent conversions of the ampoules were found to be about 2% of the control ampoules. This seems reasonable as the skin contains UV absorbing compounds, including DNA and proteins. Furthermore, the stratum corneum can also cause reflection of UVB radiation.

Results
Figure 1. Through exposure to sunlight, 7-DHC is converted to vitamin D₂, which is then structurally altered to become vitamin D₃.

Figure 2. The spectrophotometric output of the prototype LED with a peak at 295 nm.

Figure 3. The spectrophotometric output of the new LED with a peak at 295 nm.

Figure 4. The prototype LEDs when turned on. Both types of LEDs emit a bright blue visible light.

Figure 5. Six ampoules with epidermal samples placed on a Styrofoam holder over the LEDs.

Figure 6. The ampoules were held in a Styrofoam holder over the LEDs.

Each skin sample was then submerged in 65°C water to recover the epidermis by scraping it off and placing it in methanol. The methanol solution was sonicated and incubated at 50°C with an additional 30 min 30 sec.

Figure 7. The average percent conversion of 7-DHC to previtamin D₂ was higher for the new LED system. The LEDs consistently performed more efficiently, showing improved production of previtamin D₂.

Figure 8. The percent conversion of 7-DHC to vitamin D₂ in the skin was approximately doubled when the MED exposure was doubled.

Figure 9. HPLC chromatogram of the epidermis from the skin sample exposed to 1.5 MEDs.

Figure 10. The relation between MED output and average percent conversion when ampoules were all irradiated for the same amount of time for each new LED.

Figure 11. HPLC chromatogram of the epidermis from the skin sample exposed to 1.5 MEDs.

Figure 12. Normal skin sample exposed to 0.75 MEDs, about 13 IU of Vitamin D₂ was produced. Therefore, in an area of skin the size of a standard piece of letter paper, about 121,500-182,325 IU of Vitamin D₂ can be produced with just 4 min 12 sec of irradiation.

Discussion
The total average percent conversion of the prototype LED was found to be 3.9% +/−0.3, while the new LED's was found to be 5.0% +/−0.7. The new LED's percent conversion is therefore about 56% more than the prototype's.

From this, the more recently developed LED seems to demonstrate a greater producing ability, and therefore higher efficiency. This is consistent with the manufacturer’s claim. In addition, statistical testing was used to ensure that there was a significant difference. The calculated p-value was found to be less than 0.05, indicating that our results were significant.

A linear relation between the measured MED output and the percent conversion was observed when ampoules were irradiated over the new LEDs for the same duration.

As expected, the LED with the highest MED measurement had the highest average percent conversion and the one with the lowest had the lowest percent conversion.

Vitamin D₂ was detected in the skin samples. The fact that the percent conversions of the ampoules and skin samples doubled when exposed to double the MEDS confirms a direct relation between the two.

Based on the results of previtamin D₂ (the ampoules) and vitamin D₂ (for the skin samples), the percent conversions of the skin samples were found to be about 2% of the control ampoules. This seems reasonable as the skin contains UV absorbing compounds including DNA and proteins. Furthermore, the stratum corneum can also cause reflection of UVB radiation.

Conclusion
From the data collected, the more recently available LED proves itself to be more efficient in production of previtamin D₂.

The apparent improvement in production efficiency shows that the new LED's crystal is more effective and efficient in emitting UVB radiation.

With a higher production efficiency, this LED can produce the same amount of vitamin D₂ in even shorter duration.

This is an important advancement for the development of medical devices that can be used for treating patients without the ability to absorb sunlight.

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