Introduction

Vitamin D is known to have numerous biological effects, ranging from preventing autoimmune diseases and cancers to improving bone health. The cutaneous production of vitamin D occurs when UVA radiation penetrates into the skin and is absorbed by 7-dehydrocholesterol (7-DHC), levels of 7-DHC are thereafter broken, resulting in the conversion of 7-DHC to previtamin D₃, then structurally rearranges into vitamin D₃ through a temperature-dependent process. Therefore, previtamin D₃ production can be equated to vitamin D₃ production for analysis purposes.

While this solar ultraviolet radiation has the beneficial effect of producing vitamin D₃, many are wary of exposing themselves to such radiation through the sun or artificial means due to DNA cross-linking and oxygen species that can cause significant DNA damage. This could be linked to skin wrinkling and non-melanoma skin cancer.

Due to the different spectral outputs of each lamp, it takes varying amounts of time for each lamp to emit 1.00 MED (minimal erythema dose, a unit to measure radiation). These times are 202 seconds, 117 seconds, and 40 seconds, for lamps E1, E2, and E3, respectively.

This study will evaluate the differences in efficiency of the three UV lamps in producing vitamin D₃ and minimizing DNA damage.

This research will help to provide greater insight into the optimal design of UV lamps to maximize vitamin D₃ production while minimizing DNA damage.

Methods

Skin Samples/Preparation

1. Surgically obtained Figure 1 samples are irradiated for 1.00 MED using each of the three lamps. One piece of skin was irradiated using the UV lamp and the other piece of skin was irradiated using the visible wavelength (E2 and E3).

2. Irradiation under lamp E1 is accumulated by 200 MED, 117 MED for lamps E2 and E3, respectively.

RNA Analysis

1. The procedure was similar for RNA extraction using a Tri-reagent.

2. Equal parts of RNA were then treated with 3 M sodium acetate at pH 5.2, followed by ethanol precipitation.

3. Samples were then dried under vacuum and were run on 1.5% agarose gel.

Nitric Oxide/DNA Damage Analysis

1. The skin samples were decanted and the DNA was separated using a high-performance liquid chromatography (HPLC) system used for chemical analyses to separate and quantify components in a medium.

Results


Discussion

The results from the vitamin D₃ analysis indicate that lamp E1 was the most efficient, resulting in 21.4% of vitamin D₃ production, while lamps E2 and E3 were less efficient, with percentages of 14.8% and 2.7%, respectively.

The nitric oxide assay indicated that lamp E3 resulted in the most nitric oxide release, as nitric oxide release increased by 454% from the 0 MED baseline to 1 MED of radiation. Lamps E2 and E3 resulted in greater DNA damage, as it increased by 171% and 212%, respectively.

For Vitamin D₃ production:

○ Lamp E1 was the most efficient, followed by Lamp E2 and E3.

For Nitric Oxide Release:

○ Lamp E1 resulted in the greatest release, followed by Lamp E2 and E3.

For Nitric Oxide Damage:

○ Lamp E3 resulted in the least DNA damage, followed by Lamp E1 and E2.

Conclusions

Lamps E3 and E2 were most efficient in maximizing vitamin D₃ production and minimizing DNA damage, respectively.

This suggests that a lamp that has a UV spectral output of around lamp E3's may be the most effective for achieving both purposes.

Since lamp E3 produces the least amount of nitric oxide, it may be ideally suited for commercial development.

These results will help to identify the optimal lamp for usage when a certain effect is desired.

Will also provide greater insight into the optimal design of UV lamps to maximize vitamin D₃ production and minimize DNA damage.

Moreover, future studies could potentially look into:

○ Why there is a positive correlation between vitamin D₃ production and nitric oxide release.

○ Why lamp E2 would cause greater DNA damage than lamp E1.

○ Repeating study to verify results. This would be important as one of the major limitations of the study is that each test was run only once.

FIGURE 1. The Evaluation of Three UV Lamps in Producing Vitamin D₃, Nitric Oxide and Minimizing DNA Damage After Irradiation of Surgically Obtained Human Skin

Akhil Bedapudi¹,², Arash Hossein², Kelly Persons², Michael F. Holick²

Frisco High School, 6401 Parkwood Blvd, Frisco, TX 75034¹, Vitamin D, Skin, and Bone Research Laboratory, Department of Medicine, Boston University School of Medicine, Boston, MA 02118²

References


Acknowledgements

I would like to thank Dr. Holick, Arash Hosseini, Kelly Persons, and Grace Yoon for coordinating, facilitating, and guiding me through the research process and allowing me to work in their lab. I would also like to thank my parents for enabling me to participate in the RISE program.