

Beneficial Aspects of Ultraviolet Rays in Protective and Sound Health

Muhammad Torequl Islam^{1,2,3*}

¹Department for Management of Science and Technology Development, Ton Duc Thang University, Ho Chi Minh City, Vietnam.

²Faculty of Pharmacy, Ton Duc Thang University, Ho Chi Minh City, Vietnam.

³Department of Pharmacy, Ranada Prasad Shaha University, Narayanganj-1400, Bangladesh.

***Corresponding Author:** Muhammad Torequl Islam, Department of Pharmacy, Ranada Prasad Shaha University, Narayanganj-1400, Bangladesh & Faculty of Pharmacy, Ton Duc Thang University, Ho Chi Minh City, Vietnam.

E-mail: muhammad.torequl.islam@tdt.edu.vn

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Abstract

Purpose: Exposure to ultraviolet (UV) radiation is evident to cause some diseases in the skin and eye as well as cardiac and immune systems. However, UV exposure has some beneficial health effects, especially with UV_B and UV_A exposure.

Methods: Evidence from the databases: PUBMED, SCIENCE DIRECT, WIKIPEDIA and GOOGLE SCHOLAR were considered.

Results: UV exposure is necessary to synthesize vitamin D and melanin. Certain UV rays can treat many skin problems, microbial infections, mood disorders, oxidative stress as well as cancers. UV exposure also maintains neuronal-, cardiac- and bone health.

Conclusion: Sunlight exposure, which is the major source of UV is not only harmful but also helpful to maintain a sound health.

Keywords: Ultraviolet Ray; Sunlight; Health Effects

Abbreviations

ACTH: Adrenocorticotrophic Hormone; BP: Blood Pressure; HO-1: Heme Oxygenase 1; HIV: Human Immunodeficiency Virus; iNOS: Inducible Nitric Oxide Synthase; NO: Nitric Oxide; POMC: Proopiomelanocortin; UV: Ultra Violet; α -MSH: α -Melanocyte-Stimulating Hormone

Introduction

Ultraviolet (UV), an electromagnetic radiation (wavelength: from 11 to 399 nm) is shorter than the visible light (400 to 800 nm), but longer than the X-rays (0.01 to 10 nm). UV constitutes about 10% of the total light output of the sun, hence sunlight is an abundant source of it. Although, UV radiation exposure and carcinogenic effects on human skin is still controversial [1], but, exposure to excessive UV radiation is evident to result many acute and chronic harmful effects [2] in the eye [3], heart [4], immune system [5]. Overexposure is evident to cause direct and indirect DNA damage, leading to the development of cancer [6]. Beside pigmentation, the most deadly form of skin cancer, malignant melanoma is caused by UV exposure [7].

However, exposure to UV also has some beneficial health effects in human and other animals. This paper offers a view of beneficial health effects of UV radiation exposure.

Methods

A search was made in PUBMED, SCIENCE DIRECT, WIKIPEDIA and GOOGLE SCHOLAR databases for publishing evidences. Up until Nov 23, 2017 with the keywords 'ultraviolet rays' and 'health effects', 4,589 publications were observed. Among them, concentration was given on 65 records, covering the topics to be discussed in this paper.

Discussion

Beneficial effects of UV

Vitamin D synthesis

Vitamin D, a group of fat-soluble secosteroids responsible for increasing intestinal absorption of calcium, magnesium, and phosphate, and exerting various important biological effects, including anti-microbial (e.g. – HIV, influenza, malaria, tuberculosis) [8-12], anticancer [13], immunity [14], anti-diabetes (insulin secretion and glucose homeostasis) [15], and nervous system (depression, cognitive, dementia) [16,17], obesity [18], bone [19] and cardiovascular [20] health. Deficiency of this vitamin manifests rickets [21], osteomalacia [22]

and skin pigmentation [23]. It can act against complications in pregnancy (gestational diabetes, pre-eclampsia, small infants, high BP) [24,25], asthma [26], multiple sclerosis [27], Crohn’s disease and ulcerative colitis [28]. Vitamin D’s some other important physiological activities have been shown in figure 1.

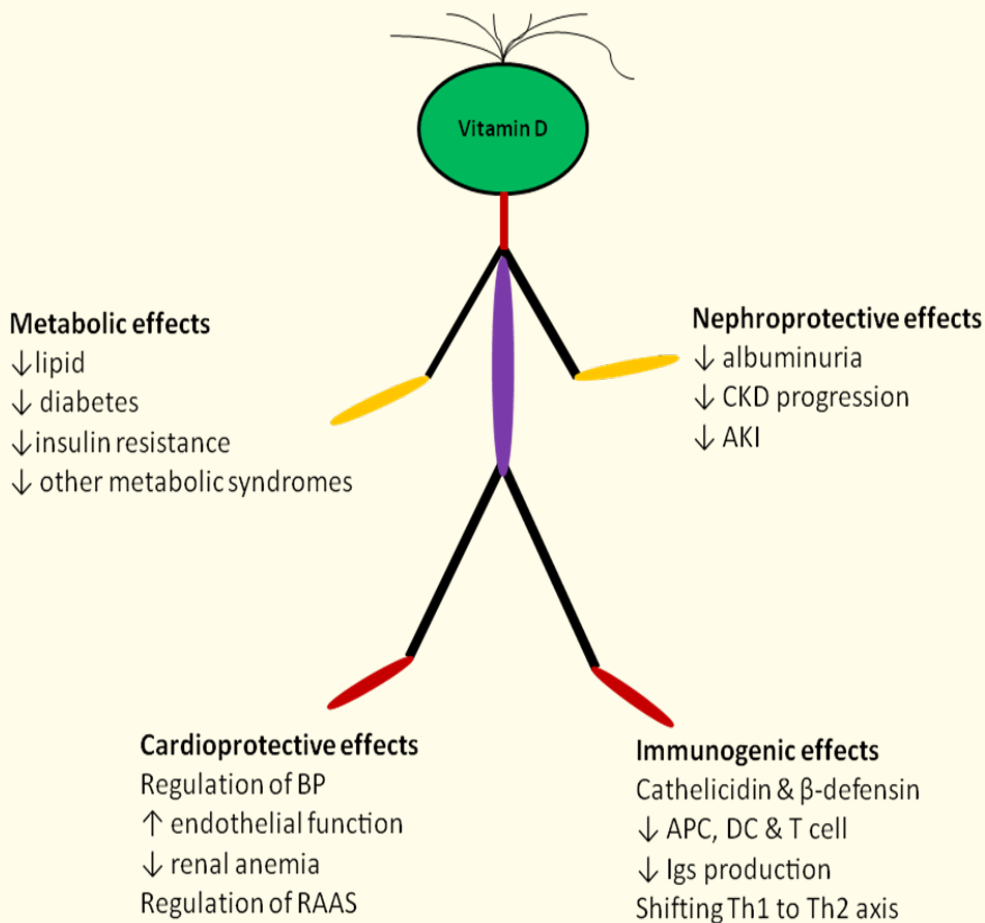


Figure 1: Physiological functions of vitamin D. [AKI: Acute Kidney Injury; APC: Antigen Presenting Cell; DC: Dendritic Cell, Igs: Immunoglobulins; BP: Blood Pressure; CKD: Chronic Kidney Disease].

Reasonable exposure to sun UV is a good source of vitamin D, one minimal erythema dose of which provides the equivalent of about 20,000 IU of this vitamin, taken as an oral supplement. It seems, only 10 - 15 minutes exposure to sun UV of 2 - 3 times per week is enough. A medium strength sunlight synthesizes sufficient amount of vitamin D within 5 - 30 minutes, however, it also depends on the darkness of skin. Exposure to sunlight at noon is more preferable for this purpose rather than at morning and at evening [29]. However, it is not necessary to expose the face to the UV, as facial skin provides a negligible amount of vitamin D₃. Patients with difficulty (including ineffective metabolism) in taking vitamin D orally can be exposed to UV_B (280 - 315 nm) radiation, to achieve a 25 (OH) D blood level [30]. Without sunlight exposure, one must need 1,000 IU of vitamin D per day to stay healthy [31]. Although, UV_C (100 - 280 nm) and near UV (300 - 400 nm) help to synthesize vitamin D, but reasonable amount is synthesized by UV_B and middle UV (200 - 300 nm), as 7-dehydrocholesterol reacts with UV_B light at wavelengths between 270 and 300 nm, with peak synthesis occurring between 295 and 297 nm [32] (Figure 2).

UV_B induces production of this vitamin in the skin at rates of up to 1,000 IU/min. In general, in animals, vitamin D₃ (cholecalciferol) is synthesized from 7-dehydrocholesterol, while in fungi vitamin D₂ (ergocalciferol) from ergosterol [33]. An excellent review has been done by Trummer, *et al.* [34] where the authors discussed UV-induced vitamin synthesis and the beneficial roles of this vitamin in our body.

Nitric oxide synthesis: role on cardiac system and other effects

Patients suffer from vitamin D deficiency have experience with low blood pressure [35]. Thus, UV_B exposure may improve this situation. On the other hand, UV_A (315 - 400 nm) UV_A stimulates inducible nitric oxide synthase (iNOS), leading cause synthesis of nitric oxide (NO) in the skin, which plays important roles in our body such as cardioprotective (vasodilation and reduce BP, and ischemia/reperfusion damage) [36], immune defense, neurotransmission, regulation of cell death (apoptosis) and cell motility, antimicrobial, antitumor [37,38], anti-leishmanial [39], and spermatogenesis [40]. NO can improve hypoxemia in acute lung injury, acute respiratory distress syndrome, chronic inflammation, atherosclerosis, relaxation of smooth muscle, and severe pulmonary hypertension. NO is known as an anti-anginal drug due to its vasodilation property, ultimately helping the ischemic pain of angina by decreasing cardiac workload. NO has upregulatory effects on protein 53 (p53), thus the tumor suppression property. It also inhibits DNA damage by interfering superoxide anionic radical (O₂^{•-}) and hydrogen peroxide (H₂O₂) action; inhibit angiogenesis, metastasis and tumor growth [41]. NO synthesis region is shown in figure 2.

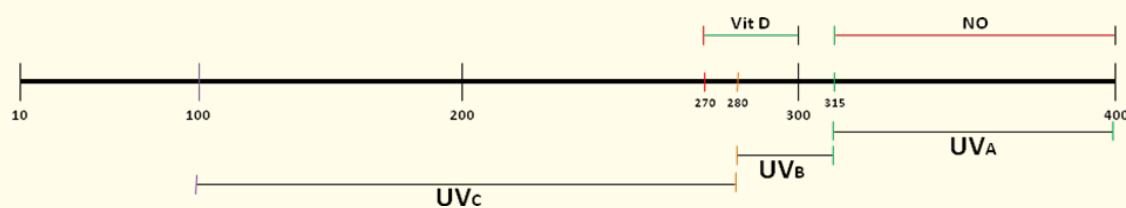


Figure 2: UV range and synthesis regions of vitamin D (Vit D) and nitric oxide (NO).

Mood enhancement and related events

Serotonin, a monoamine neurotransmitter that is thought to provide sensations of happiness, wellbeing and serenity to human beings [42], therefore, changes in its levels changes mood [43], bone density, and even sexuality [44]. The production of serotonin is in direct proportion to the degree of bright sunlight the body receives [45]. Moreover, vitamin D promotes the creation of serotonin.

Exposure to sunlight has been linked to improved energy and elevated mood [46], it may be due to stimulation of proopiomelanocortin (POMC) promoter and production of an opioid β -endorphin, leading to mood enhancement and relaxation [47].

Generally, the α -melanocyte-stimulating hormone (α -MSH) and adrenocorticotrophic hormone (ACTH), converted products of POMC exert a protective type anti-inflammatory effect and relieve irritation and local inflammation in UV-exposed skin [48,49]. UV-mediated some important biological effects have been shown in figure 3.

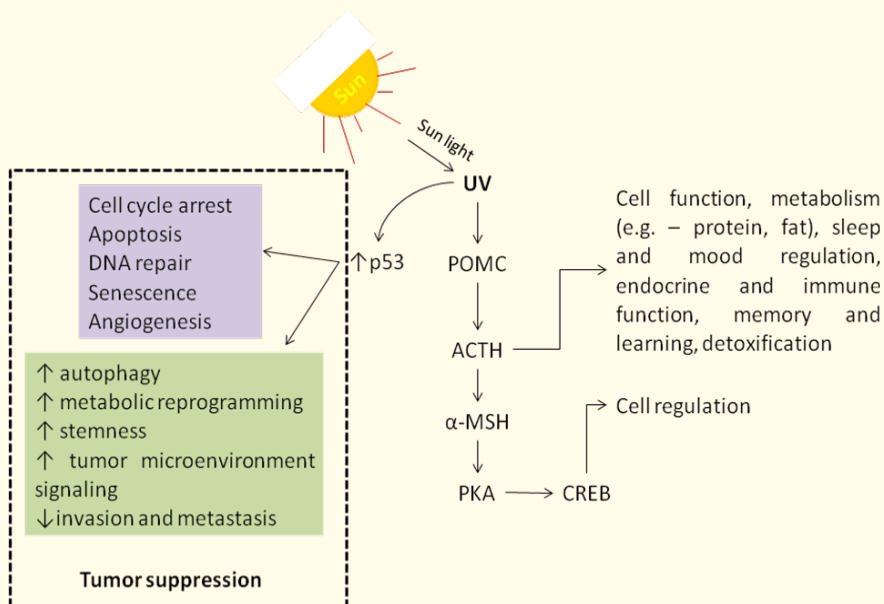


Figure 3: UV from sun light and its effects on biological system. [Ultraviolet (UV) from the sunlight after stimulating the proopiomelanocortin (POMC) can induce adrenocorticotropic hormone (ACTH), which eventually upregulates alpha-melanocyte-stimulating hormone (α -MSH), leading to upregulation of protein kinase (PKA) and cAMP-response element binding protein (CREB). The overall results are cell function, metabolism, and regulation of many nervous functions. Moreover, UV also stimulates protein 53 (p53), which is the major cause of tumor suppression].

Melanin synthesis and protective role

Melanin, an excellent photoprotectant (a brown pigment) that absorbs both UV_A and UV_B radiation and dissipates the energy as harmless heat, protecting the skin from DNA damage [50]. Moderate levels of UV exposure (sun tan) increase synthesis of melanin, followed by distribution to the neighboring keratinocytes [51,52].

Chronic UV exposure may increase melanogenesis, thickening of the horny layer, activate body antioxidant molecules (e.g. – superoxide dismutases, catalase, glutathione etc.), the DNA repair systems, and secrete cytokines (e.g. - interleukin (IL)-1 receptor antagonist, IL-4, IL-6, IL-10, IL-11, and IL-13) [53,54]. Melanin also provides protection against further UV-induced oxidative stress. An exposure to UV_A increases expression of heme oxygenase 1 (HO-1) that induces antioxidant, anti-inflammatory, antiapoptotic and anti-proliferative effects in tissues and cells, thus the protective effects against oxidative stress and tissue injury [55,56]. Figure 4 shows UV_A -induced NO synthesis, while figure 5 by UV_B -induced melanin synthesis and related other events.

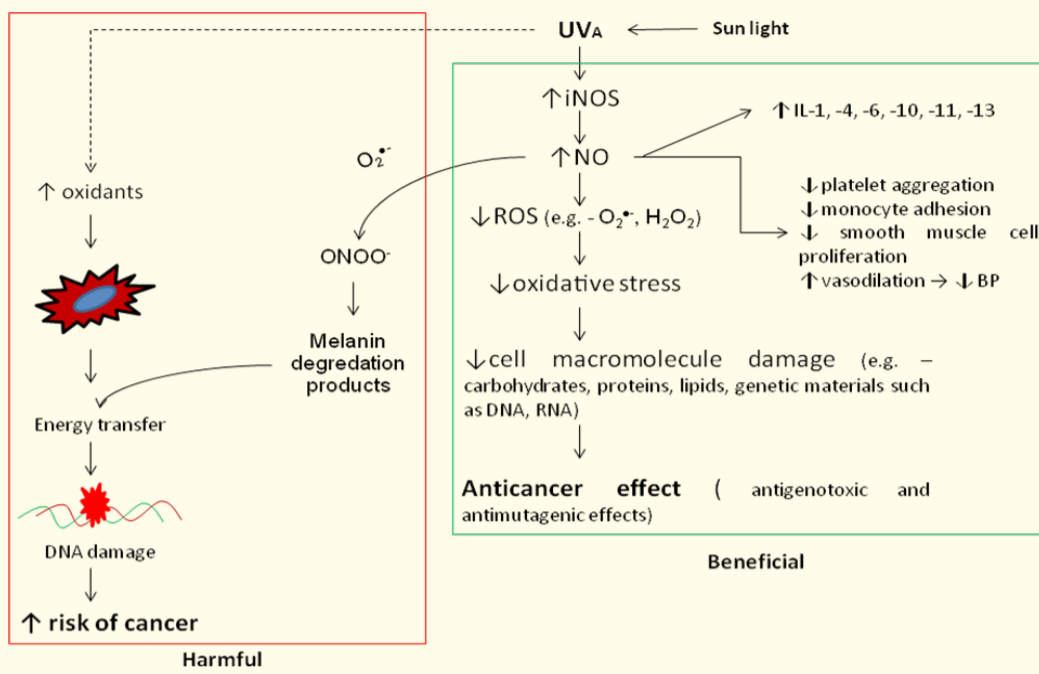


Figure 4: UV_A induced NO synthesis and related cellular events. [The ultraviolet ray A (UV_A) stimulates the enzyme inducible nitric oxide synthase (iNOS), which causes synthesis of nitric oxide (NO). The NO then decreases the activity of some reactive oxygen species (ROS), thus the reduction of oxidative stress and increase in cytoprotective events. Additionally, the NO can increase the synthesis of some anti-inflammatory cytokines such as interleukin (IL)-1, -4, -6, -10, -11, -13; decrease the platelet aggregation, monocyte adhesion, smooth muscle cell proliferation, while increasing in vasodilation and reduction in blood pressure. NO, however, after reaction with the superoxide anion radical (O₂^{•-}) can form peroxynitrite (ONOO⁻) anion, which can augment melanin degradation products, that with the UV_A induced oxidants can cause DNA damage. The latter is the major cause of UV_A induced increases in cancer risk].

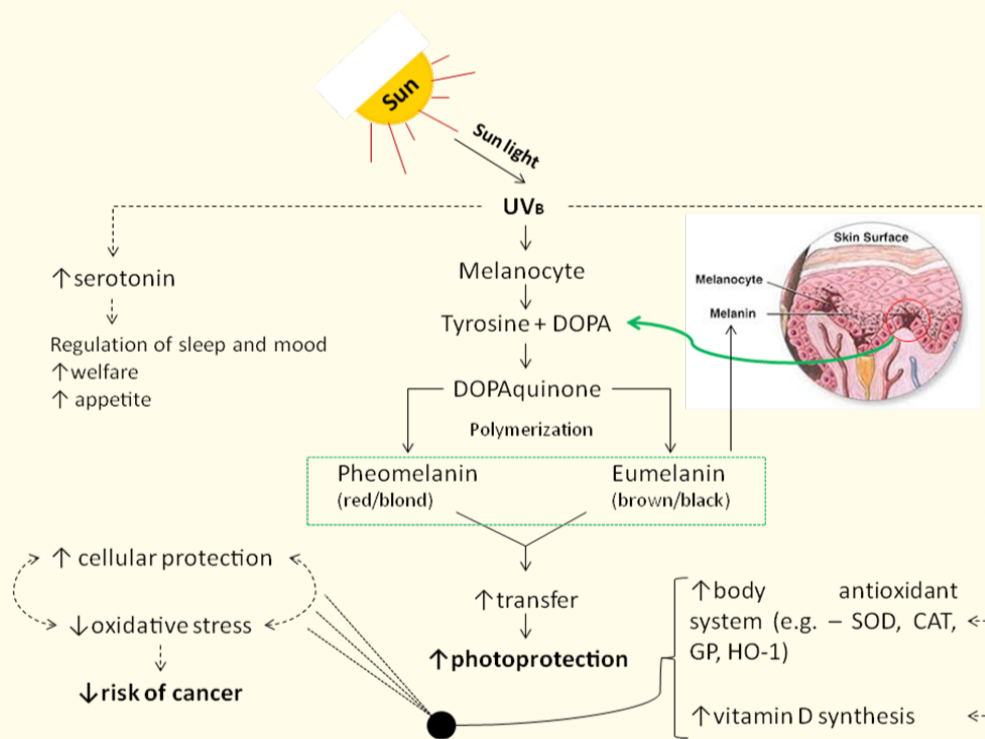


Figure 5: UV_B induced melanin synthesis and related other events. [The ultraviolet ray B (UV_B) in melanocyte in the skin induces melanin synthesis from tyrosin and 3,4-dihydroxyphenylalanine (DOPA). The dark pigment, melanin is responsible to show photoprotectivity against further UV-exposure mediated damaging effect on the skin. However, adequate exposure of this UV radiation causes synthesis of vitamin D and increase the activity of body antioxidants such as superoxide dismutase (SOD), catalase (CAT), glutathione (GP) and heme oxygenase 1 (HO-1); leading to cytoprotectivity in the host. Additionally, this UV ray is also evident to augment the levels of serotonin hormone, that controls sleep and mood, increases in welfare and appetite].

Treatment of skin diseases

UV rays have been found helpful to treat some skin diseases such as psoriasis and non-psoriatic conditions, eczema, atopic dermatitis, and sclerosing skin conditions such as morphea, scleroderma (localized), vitiligo, and mycosis fungoides [57,58]. Although long-term exposure to UV contributes to non-melanoma skin cancers, but that are rarely fatal [59].

Anticancer effects

Regular exposure to sunlight contributes to the prevention of colon-, breast-, prostate cancer, non-Hodgkin lymphoma, and skin cancer (particularly melanoma) [60].

Pain relief

Sunbathing or tanning beds are evident to reduce pain in patients with fibromyalgia [61].

Miscellaneous effects

UV treatment is closer to the vitamin D-mediated actions. It is also beneficial to treat lupus vulgaris [58,62], tuberculosis (caused by *Mycobacterium tuberculosis*) [62], and asthma [63].

The UV at 254 nm has been evident to act as germicidal/disinfectant. UV_c radiation mainly causes a photo-chemical effect in the thymines, leading to a molecular change in DNA, unusable for the essential biological process of transcription (metabolism) and replication (cell division). The cancerous effects of UV_c are still controversial, as it has been seen that this UV, like live cells can absorb by the dead epithelial cells also. Thus, the non-influential effect on the solid tumor mass, which is important to stay in the same region of origin prior to be treated. This ray of the UV generally moves in a direct line with a decrease in the intensity by increasing distance to the source [64]. On the other hand, the depth of penetration of the UVC radiation into the human skin is very smaller than the UV_A and UV_B. Therefore, the risk of skin cancer by UV_c is very low, even when exposed to intensive UVC radiation in an unprotected body part [65].

Conclusions

The sun is the major source of UV. Although, an excessive or over exposure to UV causes a number of harmful health effects, but an optimum (appropriate UV radiation and period) exposure is essential to maintain a sound health.

Disclosure Statement

The author reports no conflicts of interest. The author alone is responsible for the content and writing of this paper.

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