Daylight, architecture and people's health

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Abstract

While the evidence linking light to a plethora of health issues is plentiful, building industry and its regulatory bodies are yet to address this issue in a manner that reflects its saliency. It has been suggested that one way to cultivate support for daylighting legislation is to underscore its health effects. Though these may be long term ones, they are, nonetheless, real and should be taken into serious consideration. Many cities around the world have now zoning ordinances that legislate public access to sunlight in streets and public parks, but this legislation still doesn't go far enough to command the presence of sunlight inside people's homes and workplaces. For the most part, sunlight (or daylight) is still considered as an amenity in our living and workplaces. The question that remains unanswered is whether it is really only an amenity? This paper examines the relationship between light and human health and discusses daylighting standards in light of this relationship.
Keywords: sunlight health vitamin D lighting standards.

1 Introduction

Neither current lighting design guidelines nor the illumination standards address health issues related to light and building occupants despite the large body of evidence connecting light to range of health issues. Lighting standards have been largely based on visual performance as the sole criterion for prescribing lighting quantities (Boubekri [1]). The use of visual performance as the single criterion for prescribing illuminance levels, concerns about energy efficiency and consumption and improvement in lighting technologies have caused requirements for light levels to decrease over the last fifty or sixty years (IES [2, 3]). Research indicates that electric lighting alone cannot address health needs of the occupants. In fact, electric light may be the cause of several health problems. If one must address the health issues, it becomes necessary to look at daylighting

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not only to provide sufficient light levels to perform visual tasks or as an energy saving solution but also to be a therapeutic and healing agent for building occupants.

The effects of light may be positive or negative depending on quantities and duration of exposure. Overexposure to sunlight, for example, may cause skin cancer; underexposure, on the other hand, can cause insufficient amounts of vitamin D and subsequently a whole range of other illnesses.

It is also generally accepted that people feel better under daylight conditions. Although we may not yet know or understand all the psychological causes of the positive or "feel good," effects of natural light, medical science has provided ample information that sheds light on the causal relationships between light and some physical aspects of human health.

2 Population groups underexposed to sunlight

Inadequate exposure to sunlight and low dietary intake is usually the cause for the development of clinical vitamin D deficiency. Rickets, a long cured illness in most developed countries can still be found in some tropical countries because infants are swaddled and women are confined to the home. Elderly persons who are dependent on care providers for mobility, bed-ridden people, people living or working in windowless environments, and people living or working in highly dense areas with limited sunlight exposure may be at risk of underexposure to sunlight and vitamin D deficiency. A medical study in Australia examined the association between changes of seasons, high incidence of hip fracture and vitamin D levels in a population of elderly, not very mobile patients in the Tasmania region (Inderjeeth et al [4]). Of these patients, 68% either lived in institutional care or were dependent on a care-provider for mobility. Of these patients, 48% indicated going outdoors less than once a week. The results of this survey found no statistically significant seasonal variations in vitamin D concentration among these patients, and this lack of variation was attributed to the fact that patients were mostly bed-ridden or housebound. This Australian study underscores the absolute necessity of sunlight in people's lives. No matter what these patients diet was, it was not sufficient to overcome vitamin D deficiencies, which was the cause of bone frailty in these patients.

3 Sunlight and health

3.1 Synthesis of Vitamin D

The healing effects of vitamin D were observed at the beginning of the 20th century, when researchers were trying to understand the causes of rickets and find a cure for it. It was found that an antirachitic dietary factor was found in cod liver oil and named vitamin D. In 1921 the same healing effect was also observed not only in cod liver oil but also in UV radiation. The dual source of diet and light as antirachitic agents became then established. Today we know that there are two forms of vitamin D: vitamin D2 (ergocalciferol) and vitamin

D3 (cholecalciferol). D2 is the result of UV light irradiating a yeast sterol, ergosterol (provitamin D2); the second results from the irradiation of 7-dehydrocholesterol (provitamin D3), a sterol naturally found in several skin layers.

About 90% of Vitamin D of our bodies' needs comes from casual exposure to UVB (290-315 nm) portion the visible spectrum (Reichrath [5]). When skin is exposed to UV-B radiation, it converts a pro-hormone form found in the skin (7-dehydrocholesterol) into vitamin D. This compound travels to the liver, where it is converted to the serum (25-dehydroxyvitamin D or 25-OHD) (Glerup [6]). This serum is present in the blood serum and is the compound tested to assess vitamin D levels. It has been estimated that under normal conditions the skin can produce 80-100% of the body's required vitamin D (Glerup [6]).

3.2 Vitamin D deficiency and health problems

Vitamin D deficiency is linked to other serious illnesses in addition to bone frailty. Vitamin D deficiency can cause serious healthy problems for the elderly (Holick [7]) especially at the end of winter (Webb [8]) causing risks of hip fractures among older people. The principal causes of vitamin D deficiency are dietary imbalance and lack of exposure to sunlight. Supplementation of vitamin D with calcium in elderly women and men is shown to alleviate the problem of hip fractures (Dawson-Hughes *et al* [9], Chapuy *et al* [10], Trivedi *et al* [11], Bischoff-Ferrari *et al* [12]).

Studies have found that women in Arab countries of the Arabian Gulf region who cover totally their bodies suffer from vitamin D deficiency more than their western counterparts. Along with melanin content of the skin and a high number of pregnancies, low exposure of the skin to sunlight is believed to be one the major contributing factor to such deficiency (Ghannam *et a*l [13], Gannage-Yared *et al* [14], Saadi *et al* [15]). The fact that there is higher incidences of rickets cases (Dawodu *et al* [16]) and that circulating levels of bone resorption markers are higher (Gannage-Yared *et al* [14], Saadi *et al* [15]) and bone density of Arab women is low compared to their western counterparts is evidence that such deficiency has biological effects. Because bone remodeling is a dynamic process, reduction of bone resorption eventually results in a decrease in the degree of bone formation. Hypertension is supposed to be the most identifiable risk factor for heart failure. Factors causing hypertension may be genetic or environmental. Among the environmental factors, there is epidemiological evidence suggesting a link between insufficiencies of vitamin D with hypertension (Rostand [17]). UVB radiation was found to reduce arterial pressure in patients with mild hypertension (Krause et al [18]) while supplements of vitamin D reduced systolic blood pressure in elderly women who were diagnosed having low Vitamin D.

Vitamin D deficiency is believed to have multiple effects on various components of our cardiovascular systems. Its insufficiency can be harmful to the heart and blood vessels. Numerous reports suggest that Vitamin D deficiency causes heart failure, but such failure is reversible with vitamin D replenishment. Hypovitaminosis D is common amongst patients with heart failure

(Shane *et al* [19], Schleithoff [20]) but in general a causal relationship had been established between lack of vitamin D and heart malfunctions (Shane *et al* [19], Schleithoff [20]).

3.3 Does sunlight prevent cancer?

Numerous studies have established the favorable effect of vitamin D on our immune system. It is widely recognized now that the active vitamin D metabolite $1,25(OH)_2D$ is not produced only in the kidney as previously believed but in other tissues including colon, prostate, skin and osteoblasts cancer (Schwartz *et al* [21], Reichrath *et al* [22], Lehmann *et al* [23]). The vitamin D metabolite produced outside the kidneys is now considered to be an autocrine hormone (where the hormone acts on the same cell that produced it) or paracrine hormone (where the hormone acts locally by diffusing from its source to target cells in the neighborhood.) hormones, that regulate various cellular function in specific tissues including cell growth (Schwartz *et al* [21], Reichrath *et al* [22], Lehmann *et al* [23]). An association between vitamin D deficiency and various types of cancer including colon, breast and prostate cancer was found (Garland *et al* [24], Gorman *et al* [25], Grant [26]). Literature shows a latitudinal association between exposure to sunlight and decreased vitamin D serum levels has been demonstrated in the literature. Literature also indicates that there is an association between sun exposure and increased survival rate in various cancerous malignancies (Berwick *et al* [27], Moan *et al* [28]).

Vitamin D has a direct effect on drastic changes in blood pressure and renal osteodystrophy, an illness caused by chronic renal failure. One study found seasonal patterns in blood pressure variations amongst dialysis and renal transplant subject populations (Prasad et al [29]). Not only did patients register higher blood pressure in winter than during summer, but the length of daylight hours patients were exposed to also significantly affected blood pressure levels. The longer the exposure to daylight hours, the more normalized blood pressure became.

Decreased exposure to sunlight reduces vitamin D3 in our bodies. This has been established through the study of organ-transplant recipients who need to protect themselves from solar UV-exposure due to immunosuppressive medication they receive and the resulting risk to develop skin cancer. Renal transplant patients studied showed levels of serum 25(OH)D levels, a marker of vitamin D status, significantly lower than that of a control group of age and gender matched control group in a study (Querings and Reichrath [30]).

3.4 Sunlight vs Vitamin-D dietary supplements:

The debate about whether sunlight is more effective than dietary supplements in producing vitamin D in human bodies has been previously examined in two other studies, one in the United States and the other in Sweden. The results of the American study (Webb *et al* [31]) were congruous with the Australian study. Webb's investigation found that seasonal variation changes in serum 25(OH)D concentrations (Vitamin D) caused by sunlight exposure were highest in free-

living subjects and declined substantially and proportionally as the subjects became less mobile, irrespective of vitamin D dietary supplements. The Swedish investigation also confirmed these findings (Landin-Wilhelmsen *et al* [32]). The Swedish study concluded that although helpful, dietary supplements could not supplant entirely the effects of sunlight on vitamin D levels in human bodies, and that adequate measures must be taken to guarantee access to sunlight, especially for subjects who may be less mobile or have minimal outdoor activity.

4 Discussion

There is ample evidence suggesting that inadequate exposure to proper light in our everyday lives can either be the cause of many health problems and that light could be used therapeutically to overcome health deficiencies or even perhaps as preventive medicine. Despite this knowledge, the building industry and its regulatory agencies has yet to address this issue in a manner that reflects its saliency. Building illumination codes do not address the issue of light and health, and are primarily concerned with visual performance criteria.

The illumination levels suggested for therapeutic purposes are several times higher than those currently required by standards for visual task performance in most types of buildings. It is evident that it would not be reasonable from a cost and energy consumption standpoint to suggest that buildings should be illuminated at such high illuminance levels using electric light. Natural light, however, and especially sunlight when available, can supply for a few hours each day and at almost no cost, these needed high illumination levels in most of geographical location and seasons. But since research has established that one may not always count on the idea that people will get the necessary exposure to high daylight illuminance levels by spending time outdoor, and given the fact that most people spend 80 to 90% of their lifetime indoors, it becomes imperative to the necessary daylight inside our buildings. As we have shown, medical research suggests that human beings need daylight and sunlight to live. Daylighting legislation should take into consideration not only the visual performance requirements for setting up lighting standards but also health and overall wellbeing criteria. Currently, architects aren't required by law to provide natural light for buildings. It is true that most inhabitable buildings are required to have windows, but the provision of windows is addressed in building codes mostly in terms of fire safety and means of egress rather than to supply natural light to the space.

A more comprehensive approach to daylighting legislation would be one that first creates an environment that allows sunlight to penetrate buildings to achieve certain daylight levels inside buildings.

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