THE POSITIVE EFFECTS OF SUNLIGHT

an apprehensive overview on recently published studies

ESA
European Sunlight Association

EUROPEAN SUNLIGHT ASSOCIATION
VOICE OF THE EUROPEAN INDOOR TANNING INDUSTRY

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01 PREFACE

This second edition of the ESA White Book provides an update on the current scientific knowledge focusing on the health effects of exposure to the sun and sunbeds, with a special focus on UV radiation. Furthermore, it provides detailed information from a different perspective regarding awareness of moderate sun exposure.

It also aims to answer some critical questions, such as: "Which role do ultraviolet radiation and vitamin D have in the still ongoing COVID-19 pandemic?" or "How important is regular sun exposure for the immune system?".

The goal of this document is to fundamentally inform not only policy makers and stakeholders of our industry, but anyone who simply wants to know more about the complex effects of natural and artificial ultraviolet (UV) radiation on human health. Unfortunately, within the scientific community and as a consequence also in the media, misinformation through neglecting potential benefits is common. This is mainly due to false and outdated statistics deriving from a period that does not reflect today's situation anymore. Until today, many studies on sunbeds and their connection with skin cancer fall under this category.

Additionally, ESA White Book aims to contribute to creation of more balanced health messages for the general public, not only about the adverse effects but also about the often disregarded health benefits of sun exposure. After the WHO's classification of UV radiation as a group 1 carcinogen in 1992 (the same category as asbestos, plutonium and smoking tobacco), UV radiation from sunbeds was listed in the same category in 2009. Fortunately, today's health messages slowly adapt to the scientific state of the art and move away from condemning sun exposure or even preaching to avoid the sun at all costs.

As explained in more detail at a later point, a lack of sun exposure can potentially have severe consequences on the human wellbeing, including a higher mortality and an increased risk of developing several chronic diseases such as hypertension, diabetes and Alzheimer's disease.

Due to the modern lifestyle where most of the time is spent indoors a majority of Europeans is vitamin D deficient or even insufficient, a fact whose impact on health systems is still widely underestimated. Another problem is the possibility to frequently travel between climate zones, such as spending the Christmas holidays on a tropical beach, as the skin often does not get the chance to adapt to the sudden increase of sunlight. Subsequently, people get sunburns, the main risk factor for the development of melanoma.

Interestingly, the latest research is showing that vitamin D serum levels may just be an indicator of how much sunlight we're getting and that UV exposure in general is far more beneficial than just taking vitamin D supplements.

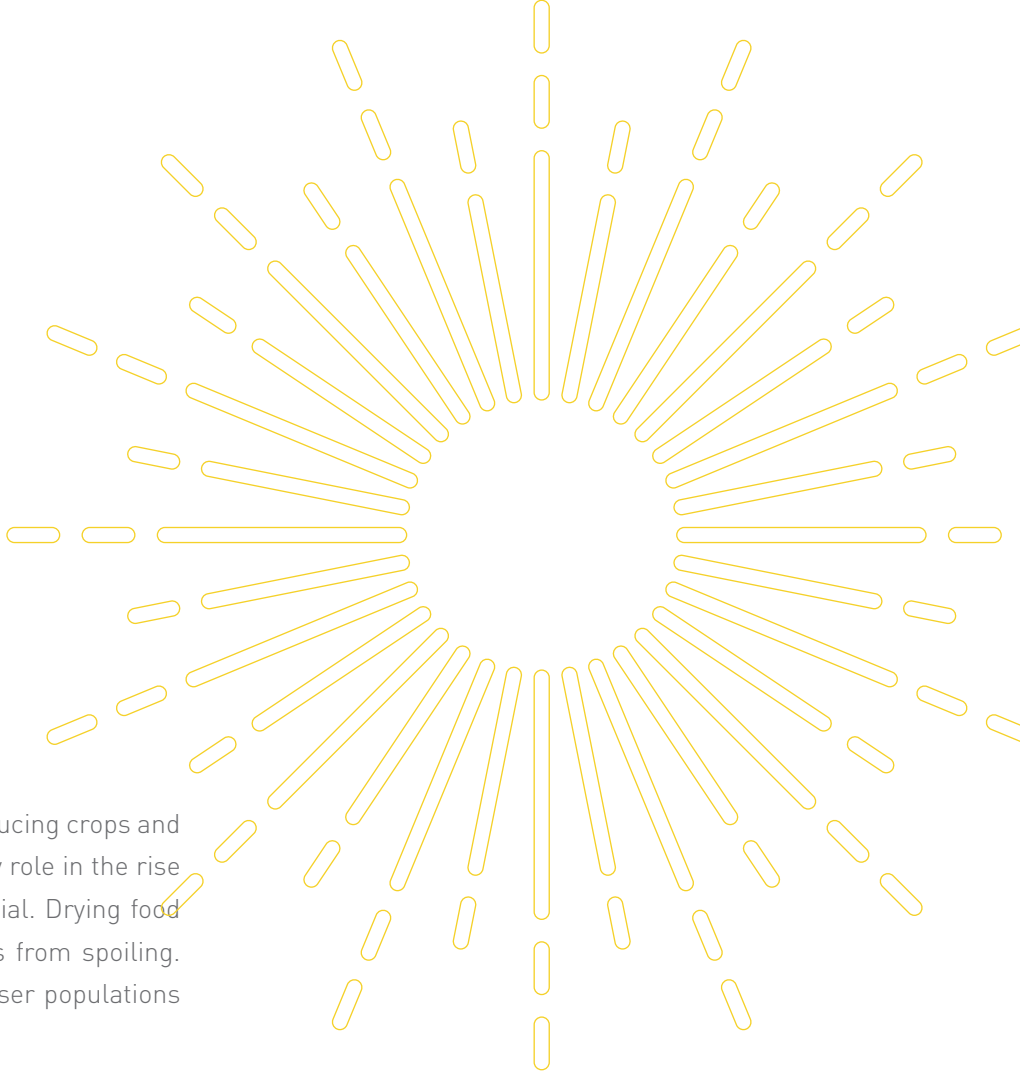
A small remark: Many of the topics could have been rolled out in an even more detailed way as there is plenty of information available and science has been making a lot of progress in the last couple of years. Nonetheless, the aim of this White Book is to keep the topics concise with the most important facts delivered to the reader in an easy-to-understand way.

02 INTRODUCTION

The evolution of the human skin

For a better understanding of the effects of sunlight on the human body, it is necessary to look a bit closer into the evolution of the human skin.

Humans, or more specifically all life on this planet, has evolved in sunlight and depended on it for its life-giving properties. The whole planet has even been bathing in sunlight for more than three billion years as these lines are written. Energy from sunlight played a crucial role in early life as it was utilized by phytoplankton to produce carbohydrates as their energy source. And while people have not been around that long, they have been using solar energy in a variety of ways for thousands of years.



In agriculture – cultivating land, producing crops and raising livestock - which played a key role in the rise of civilization, solar energy is essential. Drying food using sun and wind prevented crops from spoiling. This surplus of food allowed for denser populations and structured societies.

Early civilizations positioned buildings to face south to gather heat and light. Windows and skylights were used for the same reason, as well as to allow for air circulation. These are only a couple of examples for solar architecture.

Another important aspect in the common history of the sun and humans is the greenhouse. By converting sunlight to heat, greenhouses make it possible to grow plants out of season and in climates that may not be suited for them. One of the earliest greenhouses dates back to 30 CE, before glass was even invented.

Later, in the 19th century, solar thermal energy was used to heat water before low-cost natural gas became available for many households. Besides heating water, solar energy can also be used to make it potable – in developing countries it is still a common practice to fill soda bottles and expose them to sunlight for several hours, reducing viruses and bacteria.

In today's society, one of the most important inventions are photovoltaic cells that converse sunlight into electricity. It is estimated that sunlight accounts for 3,1% of the yearly global energy production, which is still pretty low. Especially as experts believe that 1,2% of the surface of the Sahara (roughly 335km2) would be enough to power the world.

The sun

From modern science we have learned, that the sun is a big (the earth fits 1.3 million times into it), very hot (5.500°C on the surface) and old (4.6 billion years) ball of mostly hydrogen (73%) and helium (25%) at the centre of our solar system, and all the planets orbit around it.

Life on earth, as we know it today, would not exist without sunlight as it has been influencing evolution as the source of energy. Many mechanisms such as photosynthesis have evolved and have shaped flora and fauna on this planet.

Also, or especially in the history of humans, the sun often played a central role and was even worshipped as a god in many cultures. Some even

built monuments to celebrate it. Monuments like Stonehenge in England, and the Pyramids of Egypt were used to mark the position of the sun over the course of the year.

The first accurate measurement of the distance to the sun was made by the Greek philosopher Anaxagoras. Of course, he was threatened with death for his ideas that the sun was a burning ball of fire and not a god.

It was long thought that the sun orbited around the earth, but it was Nicolaus Copernicus who first proposed a sun-centred solar system. This theory gained evidence from Galileo and other early astronomers. By the 1800s, solar astronomy was very advanced, with astronomers carefully tracking sunspots, measuring absorption lines in the spectrum of light from the sun, and discovering infrared.

For the longest time, astronomers were puzzled by how the sun generated so much energy. It wasn't until the 1930s when astrophysicists Chandrasekhar and Bethe finally developed the theoretical concept of nuclear fusion, which explained the sun (and all stars) perfectly.

Sunlight is also necessary for our survival as moderate exposure is a central part of our well-being. Historically, the relationship between the sun and humans has changed over time from benefit to risk and back to benefit. Already in antiquity, the Greeks invented the still used term of heliotherapy for the application of sunrays for healing purposes. During the Middle Age the sun had a bad reputation and it was even a sin to show too much skin. As a consequence, the wealthy citizens avoided the sun and the term "noble paleness" was born. In the beginning of the 20th century, light therapy was rediscovered by Niels Ryberg Finsen, who got a Nobel Prize in 1903 for this discovery. Nowadays the sun has a bad image again, as dermatologists and other interest group demonize it for its possible adverse effects while neglecting most of the actual health benefits.

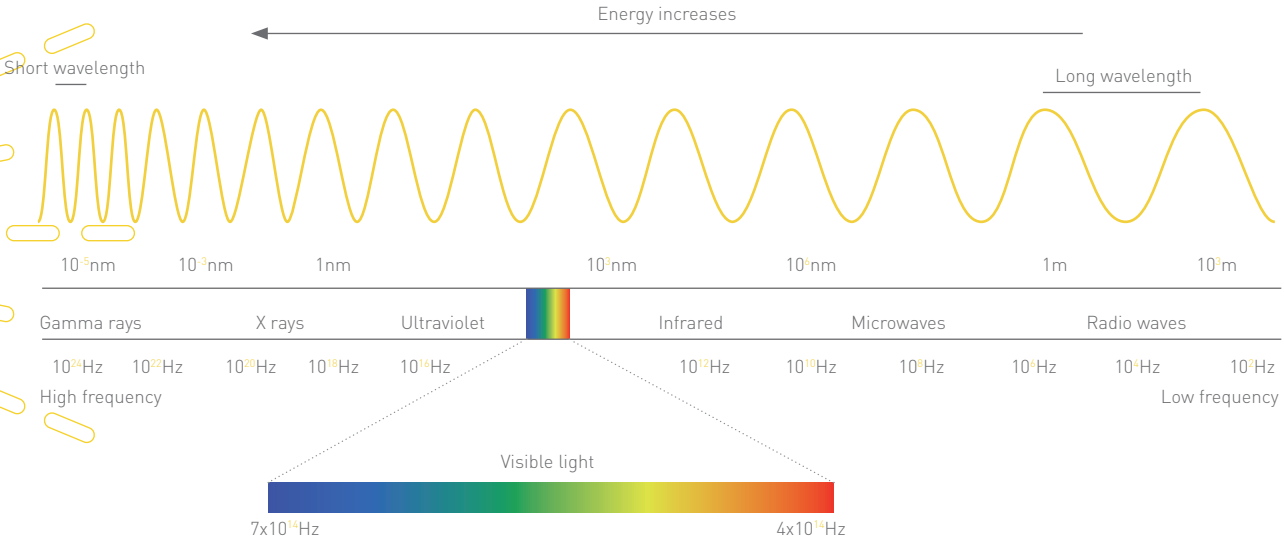
Life on earth is not possible without sunlight, yet sunlight also contains UV radiation. Is this dangerous under all circumstances? No, fortunately not! Sunlight is part of our natural environment and a little UV is good for your health. If we get too little or too much UV, however, this can be harmful to our health. The main thing to remember is that "excess" is harmful. As in so many other areas of your life, moderation is the key!

03 THE EFFECTS OF SUNLIGHT ON THE HUMAN BODY

Physical parameters of the sun

At this point, we want to provide a short introduction of some of the basic physical parameters of the sun as well as some useful explanations in order to understand the complexity of this topic.

The Electromagnetic Spectrum



The Electromagnetic Spectrum

For most of history, visible light was the only known part of the electromagnetic spectrum.

The electromagnetic spectrum consists of electromagnetic waves with frequencies ranging from below one hertz to above 1025 hertz, corresponding to wavelengths from thousands of kilometres down to a fraction of the size of an atomic nucleus. The shorter the wavelength, the higher the energy transported, and the longer the wavelength, the smaller the energy transported. The wavelength is measured in nanometre (equal to one billionth of a metre).

Within this spectrum, the electromagnetic waves are divided into separate bands:

- Between 100-380 nm: ultraviolet light
- Between 380-780 nm: visible light
- Between 780 nm – 1 mm: infrared light

Therefore, ultraviolet light contains more energy than visible and infrared light. Neither UV nor infrared radiation is visible to the human eye.

Ultraviolet radiation

When the wavelength is shorter, the energy will be higher, but the penetration in to the skin is lower. UVA and UVB play the most important role in tanning or the build-up of a natural protection. When the wavelength of the radiation is shorter, the effects are more powerful, especially on the skin. UVC, with the shortest wavelength of the various types of UV radiation, is thus the most powerful form and fortunately does not exist either in daylight reaching the earth nor in sunbeds. Of UVA and UVB, UVB has the shorter wavelength and is thus more effective (in causing sun erythema) and more powerful of the two.

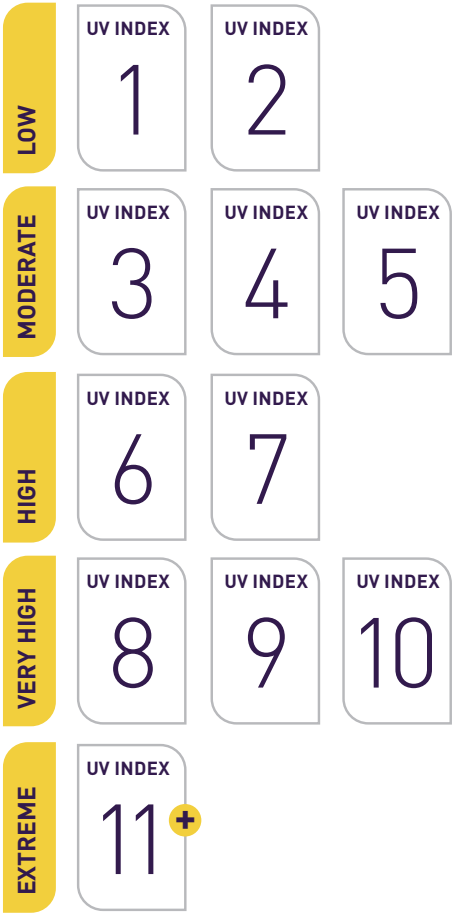
How does the world look like through the lens of a UV camera? Find out more interesting details on UV radiation in this thrilling video “The world in UV”

What does sunlight consist of?

Approximately 50% of solar rays reach the earth as visible light and 45% consist of infrared light. Only around 5% is UV radiation (UVA and UVB) and this varies widely depending on the location on earth. Of these 5%, at noon on a sunny summer day, approximately 95% are UVA and 5% UVB. Despite the low percentage, UV radiation is biologically very active.

UV-Index

The UV index is a tool, designed for communication with the general public. It is an international system of measuring ultraviolet B solar radiation for a specific day and geographical location and is the result of a common effort between the World Health Organization, the United Nations Environment Programme, the World Meteorological Organization and International Commission on Non-Ionising Radiation Protection in 1994. The UV index is a linear scale, with higher values representing a greater risk of sunburn due to UVB exposure. An index of 0 corresponds to zero UVB radiation, as is essentially the case at night. An index of 12 corresponds roughly to a midday summer day with a clear sky in the Mediterranean. A person who would begin to sunburn in 30 minutes at UV index 6, at UV index 12 the same person would expect to sunburn in about 15 minutes – twice the UV, twice as fast.



The sun and solar radiation on Earth

Daylight on the earth surface is the sum of direct solar radiation and the light from the sky (air glow). Both air glow and direct sunlight contain UV radiation. UV radiation is also present when a cloud blocks direct solar radiation. S unlight which has reached the earth's surface undergoes a few changes while traveling through the atmosphere. This means that certain wavelengths, such as UVC and a part of UVB are filtered out by the ozone layer.

The ozone layer

The ozone layer can be compared to a shell covering the entire earth. Even if there were no ozone layer, UVC would be completely absorbed by the oxygen of our atmosphere.

The thickness of the ozone layer does not affect the amount of UVA or which reaches the earth's surface much, but to block part of UVB radiation, the thickness is of utmost importance. The ozone layer is moving continuously and is thicker in the winter months than in the summer.

Interesting Facts

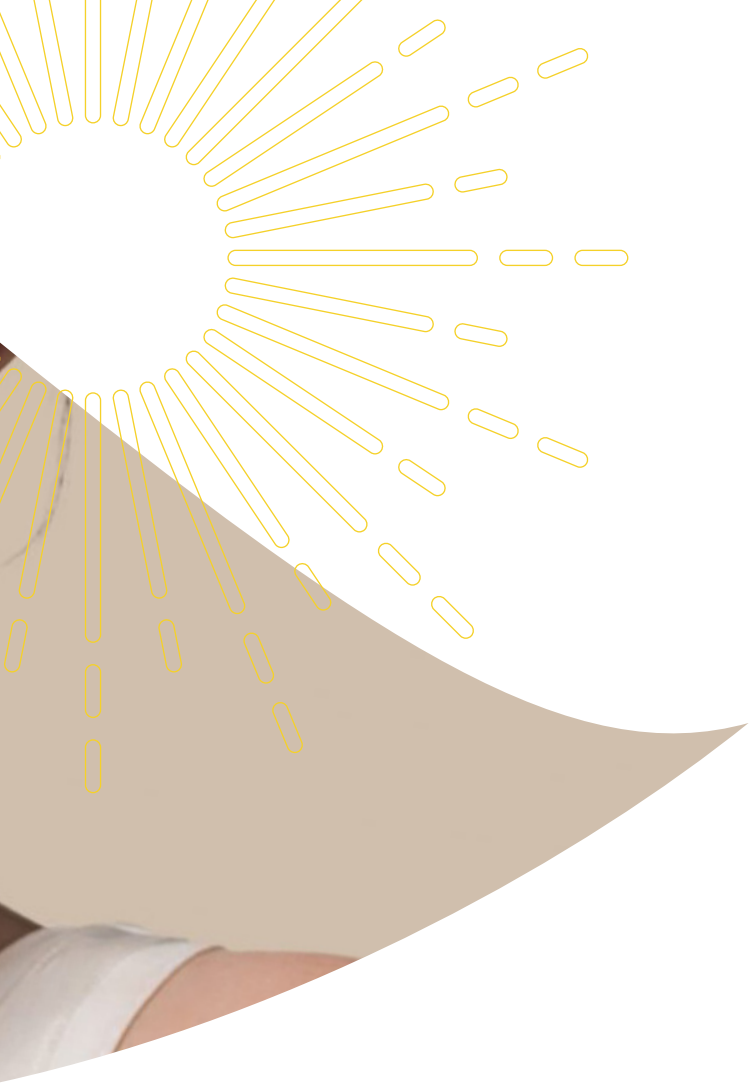
- Nutella has an SPF of 9.7 – the reason is the high amount of fat.
- Black T-Shirts (SPF 20) have a higher protection than white T-Shirts (SPF 10) because the black can absorb more UV rays.
- To travel the 149.6 million kilometre from the sun, sunlight needs exactly 8 minutes and 19 seconds to reach the earth.
- 25% of the people have to sneeze when directly looking into sunlight.

The human skin

To get an understanding of how the previously described parameters of the sun interact with the skin, it is necessary to understand the structure of the skin and its characteristics.

The skin layers

The human skin consists of three different layers: the epidermis (the outer layer), below that the dermis, and lastly the hypodermis, which extends to the bone or muscle tissue, depending on the location.



The epidermis

The epidermis consists of an outer layer of dead, horny cells, that forms the horny layer (stratum corneum) and below it the layer of squamous cells or prickle cells (keratinocytes) which are alive. The single layer of squamous cells adjacent to the dermis has a distinct name, namely basal cells (stratum basale). On average the epidermis is renewed every 28 days. The division of a basal cell creates two new cells: one remains a basal cell and the other becomes squamous. On their outward journey from basal cell layer, the squamous cells gradually become cornified and finally form the horny layer. The horny layer is not merely an unnecessary layer but has a protective function – even with regard to UV radiation, which is intensely diffused in this layer.

A feature of the epidermis is that it does not contain blood capillaries. Like the lymph vessels, these are found in the dermis. Only nerve ends can be clearly demonstrated.

The dermis

The structure of the dermis is quite different and mostly consists of connective tissue, a fibrous network. In the dermis, we also distinguish two layers, the upper dermis that contains blood capillaries that nourish the epidermis and collagen fibres which form a finely woven network. In the deeper dermis, the connective tissue consists of thick collagen bundles.

Skin thickness

The epidermis is very thin, 0.1 mm on average and the horny layer is only one-tenth of it, so 0.01 mm thick. The whole tanning process takes place in this level.

The total skin without the hypodermis, depending on the location of the body, is between 2 and 4 mm thick. The thinnest skin is around the eyes and the genitals, the thickest on the palms of the hands, the soles of the feet and the head.

Skin functions

Due to its structure, we can attribute several functions to the skin:

Overall protection of the underlying organs against mechanical and chemical threats from our environment and against all kinds of infections caused by bacteria and fungi. The presence of Langerhans cells also enables it to serve a defensive signal function for the immune system.

The skin can also be considered a large sensor, that maintains contact with the environment due to the presence of sensory organs, which determine pain, heat, cold and pressure on the skin.

Further it helps to regulate the body temperature: dilated blood vessels allow for heat loss, while constricted vessels retain heat. Also the sweat glands protect us from high temperatures by cooling the body through a process called evaporation. These glands can also excrete numerous waste products from the skin.

Another main function is the synthesis of vitamin D and other photoproducts in response to sun exposure.

The tanning process

Photoadaptation (or tanning)

The human skin adapts to UV exposure by increasing the amount of melanin and thickening of the horny layer, which has a protective effect for the DNA as it reduces the potential damaging effect of UVA and UVB. As a result, the UVA part is absorbed by the melanin, while the thickening of the skin helps to reflect the light. These effects approximately equal an SPF of 10.

Regular exposure to suberythemal doses of solar-stimulating artificial UV for three weeks decreases the ultraviolet sensitivity for erythema on average by 75%. The formation of cyclobutane pyrimidine dimers (CPD) was reduced on average by 60%.[1] More importantly, virtually no CPDs were found in the basal and suprabasal layers. DNA damage of these cells with their proliferative capacity is likely to have far more consequences than damage of the cells of higher epidermal layers that are already committed to terminal differentiation.

The tanning process

Tanning occurs in two phases. The first one is immediate pigment darkening, which describes a rapid darkening of the skin. It begins during exposure to UV radiation and its maximum effect is visible almost immediately and is caused by a change or oxidation in melanin already present in the skin. It is therefore most obvious in skin where significant pigmentation already exists and it occurs after exposure to UVA or visible light. Depending on the exposure time, the pigmentation may fade within minutes or last several days and blend in with delayed tanning.

The second phase, also called delayed tanning, is induced mostly by UVB exposure. It is the result of increased epidermal melanin and first becomes visible 48-72 hours after exposure. Both, UVA and UVB radiation start delayed tanning by creating an excited condition in the melanocytes which in turn releases more melanin into the skin.

The degree of immediate pigment darkening is primarily a reflection of the person's skin type. Delayed tanning demands larger doses of both, UVA and UVB for any given response.

Two types of melanin

Skin colour is mostly determined by pigment or melanin. People with a very dark skin have a high conversion to melanin, which is far lower in lighter skinned people. There are two types of melanin: pheomelanin (brown/red) and eumelanin (brown/black). Eumelanin can absorb UV radiation very well and it protects the skin as a result of that. Pheomelanin protects the skin less effectively and can become even less effective still if so-called free radicals are created.

Pheomelanin can mainly be found in skin types 1 and 2. There are greater quantities of eumelanin in the pigment of skin type 3 and 4. People's skin colour differs because of the varying quantities of pheomelanin and eumelanin in their skin and because of the different quantities of pigment in each cell. These relationships and the relative capacity of melanocytes to produce pigments are mainly determined by genetics.

The Fitzpatrick Scale

Developed by Thomas B. Fitzpatrick in 1975, the system estimates the response of different types of skin to ultraviolet light. Initially, it was developed on the basis of skin colour to measure the correct dose of UVA for light therapy. Later, it was altered, based on the patient's reports of how their skin responds to the sun. Up until today, the scale remains a recognized tool for dermatological research into human skin pigmentation and is used by professional sunbed salons.

Type I	Type II	Type III	Type IV	Type V	Type VI
Light, pale white	White, fair	Medium, white to olive	Olive, moderate brown	Brown, dark brown	Black, very dark brown to black
always burns, never tans	usually burns, tans minimally	sometimes mild burn, tans uniformly	burns minimally, always tans well	very rarely burns, tans very easily	never burns, tans very easily, deeply pigmented

Positive effects on the human body

Effects on the hormone balance

In addition to the above described processes, sunlight has very long-lasting effects on our hormone balance. In particular, the following hormones are formed in our brain under the influence of sunlight:

- Endorphins: They are produced by the central nervous system and the pituitary gland, act on the opiate receptors in our brains, they reduce pain and boost pleasure, resulting in a feeling of well-being. Endorphins are released in response to pain or stress, but they're also released during other activities, like eating, exercise, or sex.
- Serotonin: This neurotransmitter has a popular image as a contributor to feelings of well-being and happiness, though its actual biological function is complex and multifaceted, modulating cognition, reward, learning, memory, and numerous physiological processes.
- Melatonin: It's a hormone that regulates the sleep–wake cycle, primarily released by the pineal gland. As a supplement, it is often used for the short-term treatment of trouble sleeping such as from jet lag or shift work.

Vitamin D

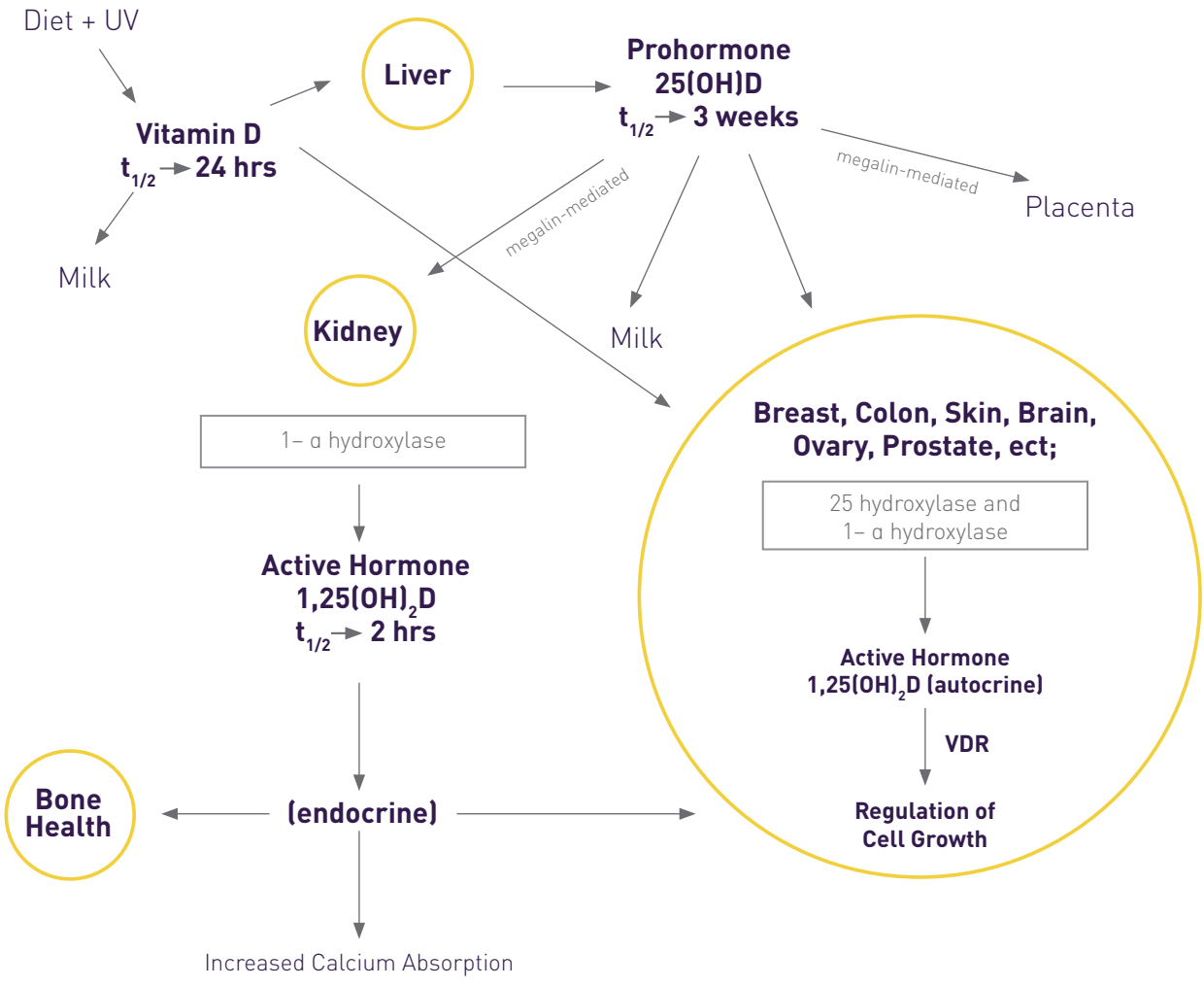
Contrary to its name, vitamin D actually is a fat-soluble hormone (more precisely: secosteroid) which is responsible for increasing intestinal absorption of calcium, magnesium and phosphate, among many other health benefits.
Recently, a huge number of studies have been published and even though there is a growing evidence on the positive effects, this nutrient is still highly controversially discussed.
Vitamin D affects the personal risk of several cancers, plays a role in hypertension and cardiovascular diseases as well as other illnesses, such as diabetes, depression, multiple sclerosis among others. The main and natural way to produce vitamin D is through UVB exposure. It's estimated that 80 to 90% of a person's daily requirement comes from UVB exposure.

Synthesis of vitamin D

In the skin, the highest concentrations of 7-dehydrocholesterol are present in the stratum basale. In humans and most mammals, 7-dehydrocholesterol is abundant in your body for vitamin D production.

When 7-dehydrocholesterol is irradiated with ultraviolet light (in the range of 290-315 nm = UVB radiation) and at least 18 mJ/cm2, it can be converted into pre-vitamin D3 through a complicated photochemically induced process. The pre-vitamin D3 is thermodynamically unstable and undergoes another transformation: Vitamin D3 is formed and subsequently enters the blood stream where it is mainly bound to the so-called vitamin D binding protein (VDBP) and transported to the liver, where it is further hydroxylated to 25(OH) vitamin D3 (calcitriol). Through the VDBP, in the target cells or organs, calcitriol acts as a steroid hormone: it is bound to an intracellular receptor protein, the vitamin D receptor, and transported into the cell nucleus. There, the vitamin-receptor-complex associates with the DNA and alters the transcription of various hormone-sensitive genes, eventually leading to changes in protein synthesis with corresponding biological effects. Additionally, each cell is also capable of converting 25(OH)D into the active hormone. However, vitamin D is circulated not only to the liver but also to all tissues in the body, many of these tissues are now known to contain not only the activating hydroxylase but also the vitamin D 25-hydroxylase that converts vitamin D into 25(OH)D.[2]

vitamin d and tissue homeostasis



Sunbeds and Vitamin D

The sun and sunbeds have a similar UVA/UVB ratio and this is why sunbeds can make vitamin D in your body. This was shown in an experiment[4], using a EN 60335-2-27 compliant sunbed, where researchers from the Leiden University investigated on the hypothesis that higher vitamin D blood levels are linked to a lower risk of getting a cold. As a result, the vitamin D blood level in sunbed users rose from 25 to 44 ng/ml and supplement users from 23 to 37 ng/ml over an 8-week period. The researchers stated: "Overall, our study showed sub-sunburn sunbed treatment to be effective in tanning and in increasing the 25(OH)D serum level, more so than oral vitamin D supplementation by 1.000 IU per day."
Furthermore, tanners have 90% higher vitamin D levels than non-tanners. A study[5] in Alberta found that regular indoor tanners had the highest vitamin D levels compared to supplement users and people who got lots of sun exposure.

Vitamin D deficiency

According to a recent study[6], vitamin D deficiency (serum 25-hydroxyvitamin D levels <20 ng/ml) is very common in Europe and the Middle East. While it occurs in < 20% of the population in Northern Europe, in 30-60% in Western, Southern and Eastern Europe, in the Middle East 80% show these levels.

"Sun and sunbeds act similarly: one quantum of radiation at a given wavelength has the same biological effect, irrespective of the source from which it comes"[3]

Prof. Johan Moan, Professor Emeritus, Plasma and Space Physics, University of Oslo, Norway

A meta-analysis[7] from 2014 that analysed data from 73 studies with >800.000 participants included, found even higher numbers for vitamin D deficiency and estimate 9.4% of all deaths in Europe and 12.8% in the United States could be attributable to vitamin D insufficiency.

Can we solve the vitamin D deficiency through food?

For most societies, food is not the primary source of vitamin D. The recommended vitamin D intake varies between 400-800 IU/day (depending on the age), while some studies suggest an intake of 1.000-4.000 IU/day or even more to maintain optimal levels.
With a diet of vitamin D-rich fatty fish, such as salmon or mackerel, eggs and meat, together with fortified food sources of milk, orange juice and cereals 600

Food	IUs per serving*	Percent DV**
Cod liver oil, 1 tablespoon	1,360	340
Swordfish, cooked, 3 ounces	566	142
Salmon (sockeye), cooked, 3 ounces	447	112
Tuna fish, canned in water, drained, 3 ounces	154	39
Orange juice fortified with vitamin D, 1 cup (check product labels, as amount of added vitamin D varies)	137	34
Milk, nonfat, reduced fat, and whole, vitamin D-fortified, 1 cup	115-124	29-31
Yogurt, fortified with 20% of the DV for vitamin D, 6 ounces (more heavily fortified yogurts provide more of the DV)	80	20
Margarine, fortified, 1 tablespoon	60	15
Sardines, canned in oil, drained, 2 sardines	46	12
Liver, beef, cooked, 3 ounces	42	11
Egg, 1 large (vitamin D is found in yolk)	41	10
Ready-to-eat cereal, fortified with 10% of the DV for vitamin D, 0.75-1 cup (more heavily fortified cereals might provide more of the DV)	40	10
Cheese, Swiss, 1 ounce	6	2

IU/day is possible. This might still not be enough vitamin D for some people to reach 20 ng/ml.
In conclusion, certain food sources can contribute to vitamin D status, but exposure to UV light (natural and artificial) or vitamin D supplements will remain key to improving vitamin D status at a population level.
Results from a study[8] suggest Vitamin D3 (cholecalciferol) to be more efficacious than the vitamin D2 synthesized in plants or mushrooms (ergocalciferol) for increasing vitamin D serum levels (25(OH)D)). These differences were bigger with bolus/intermittent doses compared to smaller ones when supplementing with daily doses.

Vitamin D supplements vs. sunlight

In order to reach sufficient serum levels of vitamin D, supplements can be an additional option to consider, e.g. for the winter months, older people or for people with skin type 1. Nevertheless, the other mentioned benefits of natural and artificial UV radiation cannot be obtained this way.
Furthermore, in case of supplementing vitamin D3 at high doses (in excess of 30.000 IU/day) for weeks, there is the theoretic possibility of developing a hypervitaminosis, which causes abnormally high levels of calcium in the blood. This can affect bones, tissues and other organs. However, vitamin D produced naturally through UVB exposure on your skin does not cause this toxicity in your body as the body limits its own production.

Cardiovascular health

Skin exposure to UVR also triggers the release of nitric oxide (NO) from dermal storage sites into the blood stream.
A growing body of evidence suggests NO is important for cardiovascular health. The NO molecule is responsible for expanding our blood vessels, increasing blood circulation in the body. This results in better blood flow to tissues and our organs, resulting in improved supply of vital oxygen and nutrients to all cells.
NO can also prevent or partially reverse arteriosclerosis (narrowing and hardening of arteries).

Effects on the immune system

Recently published studies[9] have shown that UV radiation has potent immuno-modulatory properties that influence the outcomes of malignant, inflammatory, autoimmune and infectious diseases. Immunomodulation by UVR functions both locally and systemically and involves multiple mechanisms in both the innate and adaptive immune systems.

Negative effects on the human body

"All things are poison, and nothing is without poison, the dosage alone makes it so a thing is not a poison".

This statement, credited to Paracelsus, expresses the basic principle of toxicology. It literally means that a substance can produce a harmful effect only if it reaches a high enough concentration (i.e. dose) within the body. The principle relies on the finding that all chemicals – even water and oxygen – can be toxic if too much is eaten, drunk or absorbed. Further, this provides the basis for public health standards, which specify maximum acceptable concentrations of various contaminants in food, public drinking water and the environment.

Our skin is the organ that is first hit by the sun's rays and whose reaction we first perceive and feel. The reaction depends on the intensity, the duration of the exposure and the UVA/UVB ratio:

- The more intense the radiation (e.g., higher sunshine) the more pronounced and faster is the response of the skin.
- The shorter the wavelength of the radiation, the more intense is the reaction of the skin. There is a risk of burning, which is why the UVB radiation in sunbeds is limited. However, as it also initiates the formation of vitamin D, UVB is used in a well-dosed manner.
- The longer the exposure lasts, the more intense is the reaction of the skin.

Acute damages: Sunburn

Sunburn is an irritation and inflammatory reaction of the skin triggered by overexposure to the sun or ultraviolet light, mainly caused by its' UVB rays.
The symptoms vary from person to person and depend on the intensity and duration of the exposure, among others. Redness of the skin may not be noticed for several hours after the burn has begun. Peak redness will take between 12-24 hours. Minor sunburns typically cause nothing more than slight redness and tenderness to the affected areas. In more serious cases, blistering can occur. In extreme cases, sunburns can be painful to the point of debilitation and may require hospital care.
In tanning salons, the duration of the exposure is calculated and personalized for every single customer in order to ensure consumer safety by avoiding a sunburn to happen.

In case of sunburn, further sun or UV exposure should be avoided immediately. Afterwards, cooling and moisturizing the skin with a lotion that contains Aloe Vera help the skin to heal within a couple of days. In more severe cases (formation of blisters), a doctor should be consulted.

Chronic damages: Premature aging of the skin

Although the causes of skin aging have not yet been conclusively explored, genetic factors, as well as lifestyle choices (smoking, alcohol, nutrition), environmental influences and UV exposure are suspected.
UV radiation, mainly the UVA part, can cause collagen to break down at a higher rate than normal aging. It does this by penetrating the skin, causing the abnormal build-up of a protein called elastin or by creating free radicals, both of which ultimately lead to the breakdown of collagen.
On the other hand, natural photoprotection helps reducing this risk by reducing the amount of UVA reaching the dermis.

Skin cancer

An increased risk for developing non-melanoma skin cancers (NMSC; such as basal cell carcinoma and squamous cell carcinoma), which are rarely fatal, can be one of the most severe consequences of chronic sun exposure. In some studies, regular and moderate sun exposure on the other hand also showed an inverse association to melanoma, the most dangerous form of skin cancer as well as a positive impact on many other diseases.
It is important to know that the effects of exposure to UV radiation accumulate over a lifetime. That means that a responsible behavior as an adult might not compensate for frequent sunburns in childhood.

Further, there are some main factors, that increase your risk of skin cancer, which include:

- Fair and light-sensitive skin
- MC1R variant people – red hair
- A history of sunburn (in childhood)
- Excessive ultraviolet light exposure, burning exposure
- Having many (> 50) or unusual moles (also called dysplastic or atypical moles)
- A family history of skin cancer / melanoma
- Poor Diet
- Obesity
- Lack of vitamin D

Moreover, there are various other factors such as certain inherited conditions or a weakened/ suppressed immune system among others.
Persons with one or more of these risk factors are advised to avoid direct or intensive sun exposure.

Allergic and toxic reactions

There are certain forms of allergic and toxic reactions, where the allergen is activated by light, causing a response.
Photoallergic reactions or photosensitivity are caused by drugs in which ultraviolet exposure changes the structure of the drug so that it is seen by the body's immune system as an invader. The allergic response

causes inflammation of the skin in the sun-exposed areas. These usually resemble eczema and are generally long-lasting. Many drugs in this family are topical drugs. Individuals with photoallergic reactions may initially complain about itching. This is then followed by redness and possibly swelling and eruption of the involved area. Common photoallergic drugs include some sunscreens, antimicrobials, painkillers, chemotherapy drugs, and fragrances. Once an allergic reaction has taken place, it is often permanent and difficult to reverse.

Phototoxic reactions do not lead to a permanent increase in UV sensitivity and can be triggered by certain foods (citrus fruits, parsley, etc.) or certain cosmetic products that accelerate the tanning process. These artificially increase the sensitivity of the skin to UV rays and should be avoided at all costs.

While the immediate consequences are noticeable and visible, this does not apply to the long-term or chronic effects. Due to the extremely long periods of time that lie between the excessive sun exposure and the appearance of signs of skin aging or even skin cancer, establishing a clear link is hardly possible. But as these possible consequences cannot be ruled out completely, responsible and moderate exposure to natural or artificial light is of crucial importance.

In the midsummer and in southern countries around noon, extreme caution should be taken when in the sun due to the high UV Index. Reduce your time in the sun by using shaded areas (**Caution**: Even in the shade, a sunburn is possible) or clothes and if staying out for long periods, sunscreen use is suggested.

"The advantage of a sunbed is that exposure to UV light can be controlled more precisely than casual sun exposure"

Dr. Reinhold Vieth, Department of Laboratory Medicine and Pathobiology, University of Toronto, Canada

The difference between the sun and sunbeds

As some of the data from above chapters show, we all need more sunlight.

Unfortunately, at certain latitudes, it is hardly available and, above all, not available all year round. Therefore, the question arises as to whether solariums can compensate for this deficiency and what differences exist between artificial and natural tanning.

While sunbeds' irradiance spectrum (ratio between the two types of UVR) is constant, the sun's varies according to your geographic location and to the season (the Earth's inclination to the sun). In general, a sunbed's irradiance is similar to that of the sun in terms of composition, but not in terms of UVA/UVB ratio, as this ratio differs in every place on Earth. By contrast, the spectrum emitted by a sunbed remains stable whereas it is not always obvious to people how "strong" the rays from the sun are, as they vary depending on the time of day, season and location.

Besides fostering vitamin D production, sunbeds provide measured and controlled exposure. The irradiance intensity of a sunbed doesn't change, unlike that of the sun, meaning it is possible to monitor the dosage carefully in order to prevent over exposure, leading to burns.

Depending on your skin type, a sunbed can also help to prepare and adapt your skin before you encounter increased sun exposure (due, for instance, to a change in season or geographic location such as when you go on a holiday) and therefore reduces risks of sunburn.

In order to avoid any risk of burns and to reduce the likelihood of damage to the skin due to long exposure, the EU adopted a mandatory standard in 2007 (EN 60335-2-27)10 limiting the irradiance of sunbeds to 0.3 W/m2. Put differently, a sunbed session shall have a maximum UV output that corresponds to the mid-day, Mediterranean sun (UV index of 12).

04

SCIENTIFIC EVIDENCE

There is an overwhelming amount of research papers, covering various specific topics regarding adverse and positive effects of sunlight on the human health.

While there is no doubt, that overexposure to UV radiation can have serious consequences such as skin ageing and the development of skin cancer, moderate and sensitive use provides many health benefits. As the following chapter will present, moderate, non-burning sun exposure decreases the risks of all-cause mortality, different types of cancer, cardiovascular diseases, Alzheimer and type 2 diabetes, among others.

Disclaimer: The following statements concerning listed illnesses do NOT present a medical advice. Please consult your general practitioner or specialist for individual therapy and guidance.

Prevention of rickets

This bone disorder was very common among children in sun-deprived societies in the end of the 19th century and is caused by a deficiency of vitamin D, calcium or phosphate. As a result, this lack of nutrients leads to an insufficient calcification of the growth plate in bones. Due to today's sun-avoidance policies and lifestyle, this disease, which symptoms include softening and weakening of the bones as well as poor growth and development and is seen most commonly in children 6-24 months of age, is having somewhat of a comeback. According to the NHS, in the UK, there were 101.136 admissions in 2017-2018 where vitamin D deficiency was a primary or secondary factor in the admission, a rise of 34% in a year. Additionally, there were another 474 admissions where the main or secondary reason was rickets, up from 445 the year before.

In the early 20th century, doctors found that cod liver oil and UV radiation/sunlight are able to cure rickets, which finally led to the discovery of vitamin D in 1921. Today's approaches to avoid this illness also focus on the prevention of maternal vitamin D deficiency and the provision of calcium in areas with low calcium diets.

As the authors of a study[11] about the effects of vitamin D on skeletal and non-skeletal health stated: "Vitamin D plays a crucial role in maintaining calcium and phosphate homeostasis as well as normal bone growth and mineralization."

European Sunlight Association

Osteomalacia & Osteoporosis

In adults, who are suffering from the same, above mentioned symptoms, this condition is called osteomalacia. Normally, bones consist of an inner soft mesh (the matrix) covered by a hard outer shell (the cortex) made up of minerals, mainly calcium and phosphorus. In patients with osteomalacia, this mineralization process doesn't take place properly, which leads to softened bones without a mineral covering.

Often, people who must stay indoors, who live in climates with little exposure to sunlight, who have dark skin pigmentation or who use very strong sunscreen develop this illness. Furthermore, other health conditions, such as cancer, kidney failure or a liver disease may cause osteomalacia.

Osteoporosis, which literally means "porous bone", is another bone disease in which the density and quality of bone are reduced. As bones become more porous and fragile the risk of fracture is greatly increased. The loss of bone occurs silently and progressively. Often there are no symptoms until the first fracture occurs.

According to the International Osteoporosis Foundation 1 in 3 women and 1 in 5 men over 50 are at risk of an osteoporotic fracture. Globally, this leads to an estimated osteoporotic fracture occurring every three seconds.

Recently, scientists[12] argue whether or not vitamin D and calcium supplements can improve the bone density and therefore reduce the consequences of osteomalacia and osteoporosis as results have been non-conclusive.

While a study[13] found a significant 15% reduction of total fractures in a daily setup with vitamin D plus calcium, others suggest that there is no benefit.

As the ability of synthesizing vitamin D in the skin decreases with age, scientists[14] recommend older people to either take supplements or simply stay longer outdoors in the sun. Common treatment of osteoporosis often also includes taking vitamin D supplements. Although, opinions differ on the exact amount of supplements in order to reach optimal serum vitamin D levels for human health.

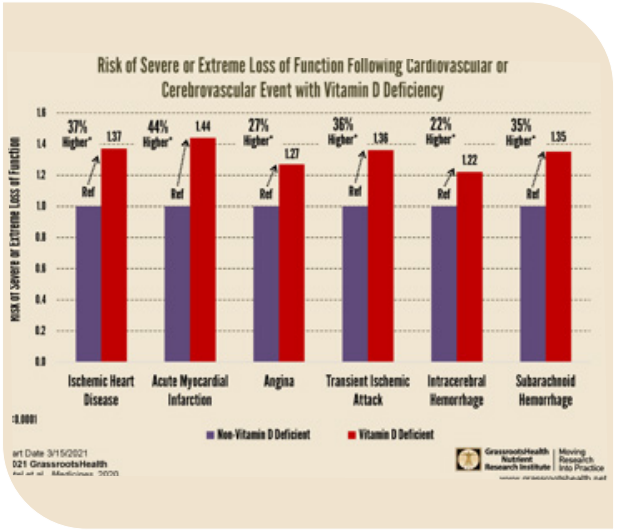
Cardiovascular diseases (CVD)

Cardiovascular diseases are a group of disorders of the heart and blood vessels and are the number one cause of death globally. In 2016, an estimated of 17.9 million people died from CVDs, which represents 32% of all global deaths, according to the World Health Organization (WHO).

In comparison, according to the World Cancer Research Fund, over 1,2 million non-melanoma skin cancers were diagnosed globally in 2020. The number for melanoma reached a total of 324.000 cases. These numbers only reflect the incidence and not the actual mortality.

To put in bold words: For every person, who dies of skin cancer, more than 100 die from cardiovascular diseases.

The scientific literature shows different functions of vitamin D in the cardiovascular system, e.g. the regulation of blood pressure or protection against oxidative damage and atherosclerosis. Further, the number of cardiovascular diseases is long and



"Our results are exciting as they suggest that if we can raise levels of vitamin D within norms, we should also affect rates of CVD. In our study population, by increasing vitamin D-deficient individuals to levels of at least 50 nmol/L, we estimate that 4.4 per cent of all CVD cases could have been prevented."
Professor Elina Hyppönen, University of South Australia

includes hypertension, congestive heart failure or peripheral artery disease among others.
Regarding the scientific evidence, one study[15] looked into data from patients that were admitted to hospitals with different CVD conditions and found that the prevalence of congestive heart failure, acute ischemic stroke, and transient ischemic attack was significantly higher among those with vitamin D deficiency compared to those without deficiency. The study also found that those with vitamin D deficiency had significantly higher rates of severe or extreme disability following the events, and non-home discharge from the hospital, compared to those without.
Another recently published meta-analysis[16] that comprised of a total of 79 studies including over 1,3 million participants has found that the risk of cardiovascular disease (CVD) incidence and recurrent CVD was significantly higher among people with the lowest concentration of circulating 25(OH)D.

Further evidence provide the findings from a study[17] in which incident solar UV radiation was associated with the systolic blood pressure of hemodialysis patients even after adjustment for environmental temperature showing that also vitamin D-independent pathways play an important role in preventing CVDs.

Data supporting these positive effects also come from a study[18] that has identified genetic evidence for a role of vitamin D deficiency in causing cardiovascular diseases. People with a vitamin deficiency were more likely to suffer from heart disease and higher blood pressure compared to those with normal levels of vitamin D. For participants with the lowest concentrations, the risk of heart disease was more than double that seen for those with sufficient concentrations.

Listen to this inspiring TED talk by Prof. Richard Weller "Could the sun be good for your heart?"

Cancer

Many public health messages focus mainly on the possible negative aspects of sunlight and specifically on the effects of UV radiation. Given that the development of any malignancies is a complex multistep process, it is overly simplistic to speak of single causes for most cancers. Some of the risk factors are simply the family history, diet and exercise, being overweight or just people getting older.
Regarding exposure to the sun, recent studies found that moderate UV exposure even reduces the risk for certain types of cancers significantly! Most likely this is mediated through vitamin D, although there are studies that attribute these effects to other not yet identified, vitamin D-independent pathways. There is a need for further research in this field in order to understand the underlying mechanisms better and ensure that public health messages provide the optimal advice.

Some studies[19] show a reduction in cancer risk of over 65% when the serum vitamin D levels are higher than 40 ng/ml. In several other cases, results also suggested protective effects that are independent from vitamin D.

There is reliable data that a huge number of cancers are associated with insufficient sun exposure and also low vitamin D levels. The following chapters will guide you through the most important recently published studies.

European Sunlight Association

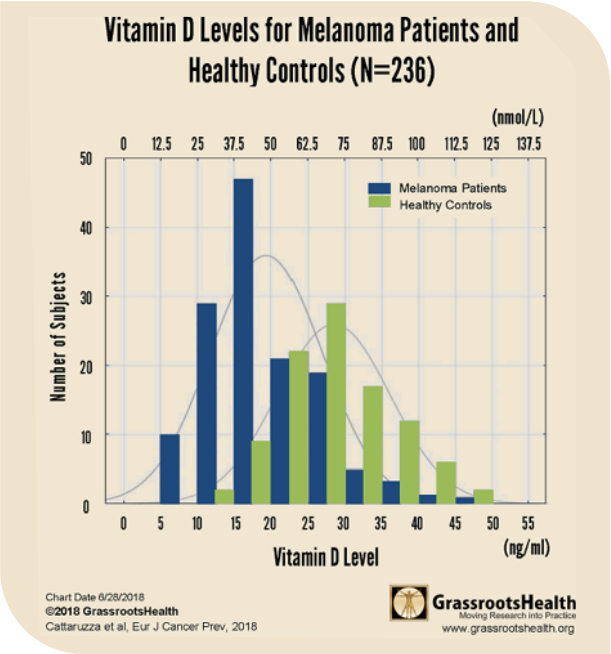
Skin Cancer – non-melanoma skin cancer and melanoma

Within the scientific community it is widely accepted that (chronic) overexposure to sunlight plays a role in increasing the risk of developing skin cancers, mainly for non-melanoma skin cancer (NMSC). The risk factors for melanoma on the other hand are more specific: intermittent sun exposure and sunburn, including the ones experienced in childhood, play a central role.

Despite prevention efforts such as raising awareness for the potential detrimental effects of the sun and the promotion of protective measures such as sunscreens, clothes, seeking shade etc., the incidence rate for both types of skin cancer are still rising. While excessive exposure to sunlight is one contributing factor, there are many other ones

Next to the stage at diagnosis, the prognosis of melanoma patients depends also on thickness and whether there is an open sore present on the tumor. According to the National Cancer Institute in the US, the 5-year relative survival rate that includes all stages is 90,5% (stage I-II (localized) 97,6%, stage III 60,3% and stage IV 16,2%) while 83% of melanomas are diagnosed at a localized stage.

In 2020, 324,635 cases of melanoma skin cancer were diagnosed globally out of which 57,043 people died.



For non-melanoma skin cancer in comparison, the numbers are less clear because of a lack of reporting in cancer registries in many countries.

In an observational study[20] that included 154 melanoma patients, a team of scientists was able to show that these patients showed lower vitamin D serum levels compared to the healthy control group. The low vitamin D status was also associated with thicker melanomas. This result is in line with other studies that recognize a deficiency status of vitamin D as a possible predisposing factor for the development of melanoma.

A team of Italian researchers found[21] that participants with vitamin D levels at or above 30 ng/ml had a 96% lower risk of melanoma compared to participants with levels at or below 20 ng/ml when adjust for age, sex and BMI.

To the similar results came a meta-analysis[22] that looked at 25 studies found that vitamin D deficiency was more prevalent among melanoma patients compared to the control group. Further, melanoma patients had a significantly higher mortality rate if they had lower vitamin D levels.

Breast Cancer

In 2020, a total of 2,3 million women were diagnosed with breast cancer and 685,000 death were registered globally. At the end of 2020, the amount of patients that were diagnosed with breast cancer in the past five years amounted to 7,8 million making it the most prevalent cancer. Risk factors can be genetic, but some lifestyle factors, such as alcohol intake, make it more likely to happen.

Results from a study[23] with data from over 5.000 women, aged 55 and older, from two randomized trials conducted at Creighton University show a 78-82% lower risk of breast cancer for women with vitamin D levels of 60 ng/ml or greater, as compared to women with vitamin D levels less than 20 ng/ml. The same result was found by another meta-analysis[24] stating that serum 25(OH)D deficiency was associated with breast cancer occurrence in the general public. As, the authors found a weaker impact of dietary or supplemental vitamin D on breast cancer occurrence, they concluded "Thus, increasing sunlight exposure may be a more effective way to prevent breast cancer than diet or supplements."

Such a positive link between vitamin D and breast cancer risk was also shown in a study[25] performed by researchers from the Danish Cancer Society. Among 38,000 women under the age of 70 the team found an association between occupational exposure to sunlight and overall breast cancer risk. In women over the age of 50, occupational exposure for 20 or more years was associated with a 17% lower risk of breast cancer diagnosis and the highest level of sunlight exposure was linked to 11% reduced odds.
In another experiment[26] researchers linked not only vitamin D to a beneficial outcome in the etiology of breast cancer, but could show that women who live in areas of higher exposure to UV during adulthood had a lower risk of breast cancer. Further, this association was most evident among women who did not report taking regular vitamin D supplements, underlining the importance of UV radiation.

"However, if the relationship (of UVA radiation and a decreased COVID-19 mortality) identified proves to be causal, it suggests that optimizing sun exposure may be a possible public health intervention."
Mark Cherrie, University of Edinburgh, UK.

Colorectal cancer

Colorectal cancer is a combined term to include cancer of the colon and cancer of the rectum and is the third most common cancer worldwide with over 1.93 million new cases in 2020 and 940,000 deaths attributed to this type of cancer[27].It is considered one of the clearest markers of epidemiological and nutritional transition, with incidence rates of this cancer increasing as previous high rates of infection related cancers decline in countries that are undergoing rapid societal and economic changes.

A meta-analysis[28] from 2020 looked at data from seven randomized controlled trials and found a 30% reduction in adverse outcomes (worsening or death) from colorectal cancer among those who supplemented with vitamin D.
Another meta-analysis[29] from 2017 even reported dose-dependent effects: While 30 ng/ml 25(OH) D levels were associated with a 33% lower risk of colorectal cancer 50 ng/ml 25(OH)D levels resulted in a 60% lower risk!

Further, also inadequate exposure to UVB light from the sun was also shown to have an association with an increased risk of colorectal cancer, particularly in older people, according to a study[30] that used data from 186 countries.

Prostate cancer

Prostate cancer is cancer that occurs in the prostate — a small walnut-shaped gland in men that produces the seminal fluid that nourishes and transports sperm. Prostate cancer is one of the most common types of cancer in men, with 1.4 million new cases in 2020. Usually prostate cancer grows slowly and is initially confined to the prostate gland, where it may not cause serious harm. However, while some types of prostate cancer grow slowly and may need minimal or even no treatment, other types are aggressive and can spread quickly.

An inverse association between serum vitamin D levels and prostate cancer risk has been shown in many studies.[31] Further, there is a dose-response relationship that shows that every 8 ng/ml increment in serum vitamin D level are associated with a 9% lower risk of prostate cancer-specific mortality.[32]

Non-Hodgkin Lymphoma

Non-Hodgkin lymphoma (NHL) is a cancer that starts in white blood cells called lymphocytes, which are part of the body's immune system. It usually starts in lymph nodes or other lymph tissue, but it can sometimes affect the skin.

As for the cancers described above, significant protective effects of sunlight and exposure to UV radiation were observed. The risk decreased between 20-33% when comparing study subjects with low and high exposure. As a study[33] showed that dietary vitamin D intake didn't improve the risk estimates, it proves the existence of a vitamin D-independent mechanism.

Lung cancer

Globally, lung cancer is one of the most common and serious types of cancer. There are usually no signs or symptoms in the early stages, which makes it hard to detect. Smoking is the main cause for this cancer (accounting for 85% of the cases), although it can also manifest in people who have never smoked. Further, the mortality rate accounts for the second highest of all malignancies.[34]

A team led by Dr. Feng from the Yangtze University in China[35] showed a dose-response relationship, as the highest circulating blood levels of vitamin D were significantly associated with a lower risk. For every 4 ng/ml increase in vitamin D, an 8% reduction in the risk of lung cancer and a 7% reduced mortality was found.

Also, patients with the highest vitamin D levels also had the longest survival rates, as shown in a study[36] that followed 210 lung cancer patients for up to 18 years.

Leukaemia

Leukemia is the cancer of the body's blood-forming tissues, including the bone marrow and the lymphatic system.
Multiple studies have suggested that vitamin D plays a role in leukemia. Researchers from the University of California[37] found that individuals residing at higher latitudes with lower sun exposure, such as the U.S., Australia, New Zealand, Canada and Ireland, were at least twice as likely to have leukemia as individuals residing in countries closest to the equator, such as Nigeria, Bolivia, Samoa and Madagascar.
Ultimately, the researchers concluded: "Importantly, these results suggest that increased levels of UVB irradiance and vitamin D may help prevent development of leukemia."

Autoimmune diseases

According to the National Stem Cell Foundation, nearly 4% of the world's population is affected by one of the more that 80 different auto-immune diseases. The most common and well-known include type 1 diabetes, multiple sclerosis and rheumatoid arthritis.

A new analysis[38] investigated the relationship between vitamin D and the prevalence of autoimmune diseases. Supplementation with vitamin D led to a 22% decreased incidence of diagnosed auto-immune diseases in comparison with a placebo control group. The risk decreased even further (by 39%) when diagnosis during the first two years was excluded.
Further, the participants of the study were only taking 2000 IU vitamin D per day without adjusting intake to reach certain target levels. This means that additional benefits that could potentially exceed the actual results of the study might have been achieved if enough supplement was given in order to reach target levels of 40-60 ng/ml of vitamin D.

Diabetes

According to the International Diabetes Federation, approximately 537 million people worldwide suffer from diabetes, the majority living in low- and middle-income countries. Further, around 6,7 million deaths can be directly attributed to the disease each year. Additionally, 541 million adults are currently at the risk of developing type 2 diabetes. Over the last few decades, both the number of cases and the prevalence have been steadily increasing.

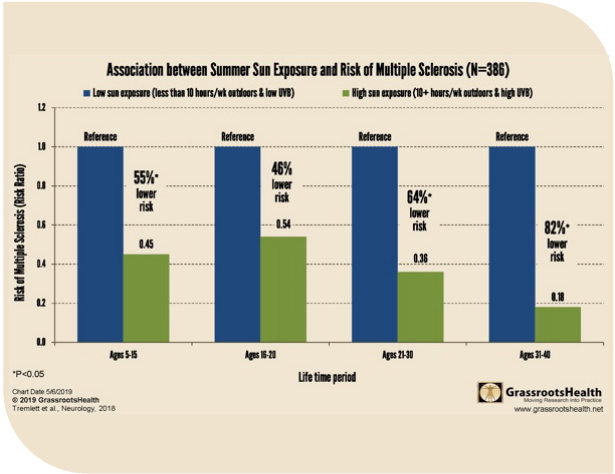
Vitamin D is believed to help improve the body's sensitivity to insulin – the hormone responsible for regulating blood sugar levels – and thus reduce the risk of insulin resistance, which is often a precursor to type 2 diabetes. This was shown in a study[39], using vitamin D supplementation as well as in a study[40] that examined the influence of bright sunlight on metabolic health. Scientists further suspect that vitamin D may even help regulate the production of insulin in the pancreas, but the data for this remain non-conclusive.
Further studies[41] showed that the risk of developing type 2 diabetes in people with 25(OH)D blood levels lower than 30 ng/ml was five times that of those whose levels were higher than 50 ng/ml.

Multiple Sclerosis

Multiple Sclerosis (MS) is a chronic condition that affects the brain and spinal cord. In MS, the coating that protects the nerves (myelin) is damaged and causes a wide range of symptoms. In milder cases, there may be numbness in the limbs, in severe cases paralysis or vision loss might occur. It is two to three times more common in women than in men, and diagnosis usually occurs between the ages of 20 and 50 years. According to the International Multiple Sclerosis Federation, an estimated 2,8 million people live with MS worldwide. Since 2013, MS prevalence has increased in every region of the world.

A study[42] from the year 2020 showed that low exposure to sunlight increased the risk for MS. The results indicated both a direct and an indirect effect of sunlight exposure, most likely through the synthesis of vitamin D, on the risk of MS.

Even more impressive numbers were found in a study[43] from 2018, that examined the relationship between sun exposure and risk of developing MS among 151 cases. Researchers assessed both the amount of time spent in the sun and ambient UVB, which is a measure of the amount of UVB in a particular residential area based on latitude, altitude, and cloud cover. The research team found that those living in high UVB areas before the onset of MS had a 45% lower risk of MS compared to those living in low UVB areas. Also, those who spent 10 or more hours per week outdoors in the summer in high UVB areas during ages 31-40 had an 82% lower risk of MS compared to those who spent less than 10 hours per week outdoors in low UVB areas.



Additionally, a meta-analysis[44], including 94 studies, adds further evidence suggesting that there is a significant positive gradient in MS prevalence with increasing latitude. In other words, potentially modifiable environmental factors, such as sun exposure, are strongly associated with MS risk.

The above findings support the relevance of sun exposure and the positive effects for the prevention of MS and are especially relevant for those with a genetic predisposition to MS.

Respiratory di seases & the flu

Respiratory diseases affect the lungs and other parts of the respiratory system and include asthma, chronic

obstructive pulmonary disease (COPD), pulmonary fibrosis, pneumonia, and lung cancer.
A global collaborative study[45] has confirmed that vitamin D supplementation can help protect against acute respiratory infections. The researchers found that daily or weekly supplementation had the greatest benefit for individuals with the most significant vitamin D deficiency (blood levels below 10 ng/ml) - cutting their risk of respiratory infection in half - and that all participants experienced some beneficial effects from regular vitamin D supplementation.

Regarding the flu, which according to the WHO results in 3-5 million severe cases worldwide each year with 290.000-650.000 deaths, there are two basic reasons, why it is more common during the winter: The influenza virus can survive longer outside the human body when it is cold and dry. Secondly, vitamin D levels tend to be lower in winter.
Vitamin D is known to have several immuno-modulatory functions, including up-regulation of antiviral peptides that are part of human innate immunity and can inactivate the influenza virus.

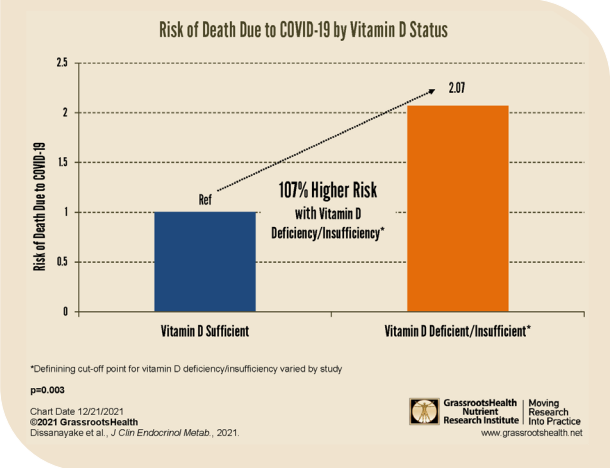
Researchers from the Karolinska Institute in Sweden have pooled a total of 43 studies[46] on the relationship between vitamin D and respiratory infections, involving almost 50,000 participants. While the total protective effect against respiratory infections was around 8%, the researchers further found that a daily dose of vitamin D is much more efficient than a bolus one given once per week or month.

Did you know?

There is a website that lists all the relevant research on the topic and provides updated numbers regularly.

COVID-19

In the end of 2019, a novel variant of coronaviruses, the SARS-CoV-2 virus caused the outbreak of what has become a pandemic that is still ongoing more than two years later. Coronavirus disease (COVID-19) is an infectious disease and most infected people experience mild to moderate respiratory illness and recover without requiring special treatment. Further symptoms can include fever, cough, shortness of breath, fatigue and headache. However, some become seriously ill and require special medical attention. As of February 2022, there have been a total of 394 million confirmed cases of COVID-19, including 5,7 million deaths.



A team of researchers from St. Petersburg, Russia, found[47] that severe vitamin D deficiency was associated with increased risk of COVID-19 and fatal outcome. In patients with severe course of the disease as well as in patients who died, vitamin D levels were significantly lower than in the patients with moderate course.
Another meta-analysis[48] showed that individuals with vitamin D deficiency were 80% more likely to acquire COVID-19 infection as compared to those who have sufficient levels.

Results from two large meta-analyses[49,50] which included a total of 54 studies with 1,4 million and 72 with nearly two million individuals respectively showed that severe deficiency, deficiency as well as insufficiency of vitamin D were all associated with admission to intensive care units. Further, patients with low vitamin D levels present an increased risk of mortality due to SARS-CoV-2 infection and a higher susceptibility with related hospitalization. In concrete numbers, vitamin D deficiency or insufficiency led to a 46% increased risk of COVID-19 infection, a 90% higher risk of developing severe COVID-19 disease and an astonishing 107% higher risk of death due to COVID-19.

Another study[51] even provided hints that the active forms of vitamin D and lumisterol can inhibit the enzymes of the SARS-CoV-2 replication machinery. The researchers have performed activity measurements that demonstrated a 10-19% and 50-60% respectively of the two proteins mainly involved in viral replication and establishing the infection.

There has been some research[52] that also linked vitamin D-independent pathways with a reduction of SARS-CoV-2 infections.
"We were able to show that higher solar energy was associated with reduced COVID-19 spread, regardless of statistical analysis method and the geographical location, possibly due to the benefits of ultraviolet radiation and vitamin D on reducing COVID-19 spread or because sunlight inactivates the virus." said Professor David M. Schultz from the University of Manchester.

Further, it has been found[53] that also UVA radiation leads to a significant 29% reduction in the mortality rate per 100 kJ/m2 increase in mean daily UVA. Similar results have been found when the method was replicated in Italy and England with a decline of 32%. This result suggests that higher ambient UVA exposure is associated with lower COVID-19 specific mortality. The researchers included only areas experiencing levels of UV too low to induce significant cutaneous vitamin D synthesis, showing that these result are independent of a vitamin D pathway.
In another interesting experiment[54], a team of the Harvard Medical School found that not only sufficient vitamin D levels and exposure to UVA decrease the risk of COVID-19 infection a subsequent hospitalization, but also exposure to UVB. Participants with the highest UVB exposure had a 24% lower risk of SARS-COV-2 infection compared to the lowest.

In general, the germicidal properties of the UVC component of ultraviolet light have been known to humanity since centuries. Today it is used to disinfect water, closed environments and biological products. Researchers from Italy have now looked into the virucidal effects of UVA and UVB radiation and found that SARS-CoV-2 is highly susceptible to UV light. Even violet light with a wavelength of 405 nm resulted in an inactivation of the virus. These results[55] offer an explanation to the reduced incidence of SARS-CoV-2 infection seen during the summer months.
The huge amount of papers, reviews and analyses published on the COVID-19 topic in such a short amount of time is astonishing and the vast majority of them shows that vitamin D deficiency is a risk factor as well as positive effects mediated through sunlight and more specifically through UVA and UVB.

"Pregnant mothers get out in the sun for a few minutes around midday and make certain your children play in the sun regularly. Just take care not to burn."

Marc B. Sorenson, Ed. D. in "Embrace the Sun"

Alzheimer's disease

Alzheimer's is the most common cause of dementia, a general term for memory loss and other cognitive abilities serious enough to interfere with daily life. Alzheimer's disease accounts for 60% to 80% of dementia cases. Worldwide, nearly 55 million people have Alzheimer's or a related dementia.

Low vitamin D levels, next to other factors also seem to play a role in an increased risk of Alzheimer's disease and other dementias. A group of researchers from the University of Bordeaux[56] analysed 916 participants, aged 65 and older, whose measurements for vitamin D status and cognitive decline were tracked for 12 years. Overall, the study found a significant association between vitamin D deficiency and faster cognitive decline, as well as a 3-fold increase in the risk of Alzheimer's disease. The authors stated: "Those participants with vitamin D deficiency and insufficiency had a significantly doubled risk of all-cause dementia. Associations appeared even stronger for the risk of Alzheimer's disease, with risks almost tripled in both deficient categories compared with sufficient concentrations."

Pregnancy

Multiple research studies have found that vitamin D levels above 40 ng/ml during conception and pregnancy support the health of the mother and the baby. Risk of preterm birth is reduced by 60%[57] almost completely eliminates pre-eclempsia[58] as well as a lower risk for post-natal depression.[59]
When comparing low levels of vitamin D (<12 ng/ml) with higher levels in early pregnancy, a 90% increased risk of multiple sclerosis in the offspring[60] as well as a 67% increased risk of type 1 diabetes in offspring when comparing low and high sun exposure during pregnancy.[61]

Inflammatory bowel disease

Inflammatory bowel disease (IBD) is a term mainly used to describe two conditions: ulcerative colitis and Crohn's disease, which are long-term conditions that involve inflammation of the gut. People of any age can get IBD, but it's usually diagnosed between the ages of 15 and 40.

Vitamin D protects the gut barrier by regulating tight junction proteins and inhibiting intestinal apoptosis. Vitamin D enhances innate immunity by inducing antimicrobial peptides and regulates adaptive immunity by promoting anti-inflammatory T cells and cytokines.
In some studies, up to 60% to 70% of people with IBD have insufficient vitamin D levels.
According to new research[62] from the Australian National University, children who spend half an hour a day outside in the sun reduce their risk of IBD significantly.

Immune system

Deficiency in vitamin D is also associated with increased autoimmunity as well as an increased susceptibility to infection.
A team from the University of Edinburgh[63] focused on how vitamin D affects a mechanism in the body's immune system - dendritic cells' ability to activate T cells. In healthy people, T cells play a crucial role in helping to fight infections. In people with autoimmune diseases, however, they can start to attack the body's own tissues.
The researchers stated: "Low vitamin D status has long been implicated as a significant risk factor for the development of several autoimmune diseases. Our study reveals one way in which vitamin D metabolites can dramatically influence the immune system."

"We found every 10 minutes of sun exposure was associated with a lower risk of developing inflammatory bowel disease by 6 %"

Professor Dr. Robyn Lucas, ANU College of Health and Medicine, Australia

Depressive disorder

Depression is a common mental disorder. Globally, more than 300 million people of all ages suffer from depression.
As described earlier, exposure to sunlight is thought to increase the brain's release of a hormone called serotonin[64], which is associated with boosting mood and helping a person feel calm and focused. The light-induced effects of serotonin are triggered by sunlight that goes in through the eye. There it cues special areas in the retina, which triggers the release of serotonin.
Seasonal increases in sun time were associated with decreased mental health distress.[65] Other studies[66] also show a relationship between vitamin D deficiency and symptoms of depression. However, it remains unclear if low vitamin D levels are the cause or the effect of depression.

All-cause mortality due to sun avoidance

Fortunately, nowadays some public health authorities have understood the importance of moderate exposure to the sun and don't strictly recommend to avoid the sun as much as possible as it was practiced in recent years.

A study[67] claimed that based on previous research, insufficient sun exposure might be responsible for 480,000 deaths per year in Europe alone, pointing to a significant public health problem. Further, too little time spent in the sun may increase the incidence of breast cancer, colorectal cancer, hypertension, cardiovascular disease, metabolic syndrome, multiple sclerosis, Alzheimer's disease, autism, asthma, type 1 diabetes and myopia.

Further, a meta-analysis[68] by researchers from the Karolinska Institute in Sweden assessed the avoidance of sun exposure as a risk factor for all-cause mortality and found that, compared to the highest sun exposure group, the all-cause mortality rate was doubled among avoiders of sun exposure and increased by 40% in those with moderate exposure! The same group found in another study[69] that women with active sun exposure habits had a lower risk of cardiovascular disease mortality and other non-cancer mortality.

"To minimize the harms of excessive sun exposure, great care must be taken to avoid sunburn, and sun exposure during high ambient UVR seasons should be obtained incrementally at not more than 5–30 min a day (depending on skin type and UV index), in season-appropriate clothing and with eyes closed or protected by sunglasses that filter UVR."

Lars Alfredsson, Institute of Environmental Medicine, Karolina Institute, Sweden.

"Avoidance of sun exposure was a risk factor for all-cause death of the same magnitude as smoking is novel"

Professor Dr. Pelle Lindqvist, Department of Clincial Science and Education

Karolinska Instute, Sweden

05

MYTHS ABOUT UV EXPOSURE, SUNBEDS AND TANNING

A Suntan is natural

This is not the public health message we are getting today though, as sunlight and tanning are portrayed as something to be avoided at all costs. As we have tried to show in the previous chapters, sun avoidance has been repeatedly proven as harmful, as sunlight helps to keep healthy vitamin D levels in the blood, along with other photoproducts like nitric oxide, which fights chronic diseases like hypertension and arteriosclerosis. The mortality rate is twice as high in women who avoid sun exposure compared to those who were more exposed to the sun. A 2019 commentary titled "Sun Exposure Public Health

Directives"70 stated: "The public health directive regarding sun exposure and human health should be adjusted to reflect current scientific knowledge. We recommend a public health directive as follows: All persons in the world regardless of skin colour or latitude of residence, other than those with extraordinary sensitivity to sunlight, should get enough sun exposure to maintain a serum 25(OH)D level well over 20 ng/ml (desirably at 30–60 ng/ml) while taking care to avoid sunburn."

Sunbeds are basically like the sun: enjoy it in moderation!

UV emitted from sunlight and sunbeds are more similar than generally thought: the UV in midday summer sunlight is made up of about 95% UVA light and 5% UVB light. Most sunbeds emit the same, with a maximum intensity equalling the midday sun in the Mediterranean. This is guaranteed through the European standard EN 60335-2-27, limiting UV output from sunbeds to 0.3W/m2. The major difference however, is that UV from a sunbed is easily controlled to avoid overexposure by trained and industry certified operators following Professional Standards.

'The dogma, now fossilized in print, is that any tan is a sign of skin damage. Tell that to Darwin. Even if there was hard evidence that melanoma was UV-induced it would be all the more important to keep a protective tan' – Dermatology

Professor Dr. Sam Shuster, Emeritus Professor of Dermatology, Newcastle University, UK

Regular UV exposure actually lowers melanoma risk

UV has a complex and often-misunderstood relationship with melanoma skin cancer risk. Consider: indoor workers who get less UV exposure get more melanomas than outdoor workers who get regular sun. As described in the chapter 4.4.1, people with the most UV exposure, had a 5% reduced risk of melanoma. Sunburn – not regular sun – is the main UV-related risk factor and total sun avoidance is a major mistake.

Professional tanning salons and melanoma risk

Parts of the scientific community are pushing for stricter legislation or even a total ban of sunbeds71 by claiming, that it is "time to close the debate" whether sunbeds contribute to melanoma risk or not.

Not all scientific experts72 however agree with the conclusions of that publication as some questions remain open.

The same group of scientists also already highlighted the several shortcomings of previous reports such as the conclusions of the SCHEER (Scientific Committee on Health, Environmental and Emerging Risks) report from the European Commission or the WHO document on sunbeds.[73]

The article further argues that the reports, which conclude that sunbed use increases melanoma risk, "appear to be based on an incomplete, unbalanced and non-critical evaluation of the literature". Moreover, the article underlines that both reports neglected the growing evidence, showing the health benefits of UV induced vitamin D creation, which include protection against several types of cancer, a decreased risk of cardiovascular diseases, auto-immune diseases such as multiple sclerosis, metabolic disorders like diabetes or simply a longer life expectancy.

Most importantly, the reports of the SCHEER group and the WHO fail to establish a cause-effect relationship between sunbed use and any kind of skin cancer. On top of this, they both rely on outdated or irrelevant data and underestimate other important factors regarding the development of cancer, such as overexposure to the sun, smoking or drinking alcohol. Both reports are mainly based on studies that were carried out before the implementation of the current irradiance limit of 0.3 W/m2 in Europe, which is an equivalent to the Mediterranean summer sun. Also, many of the cited studies included individuals with skin type I, who are not allowed to use a sunbed in Europe.

Randomized controlled trials that have been designed to confirm the associations of vitamin D deficiency with adverse health outcomes from epidemiological studies such as cardiovascular diseases, cancer and mortality often fail to show significant effects. Some of the reasons are that many of these trials don't restrict their participants to individuals with vitamin D deficiency or allow moderate vitamin D supplementation in the control group.[74]

Exclusion criteria – who is not allowed to use a sunbed

In most countries, sunbed use is very well regulated and is excluding the following people from using it:

- Persons with sensible skin (Skin type 1)
- People with many sunburns in childhood
- Minors under 18 years
- Persons with many, large or abnormal moles
- People who have skin cancer
- People with a family history of skin cancer
- People who take photosensitive medications

Vitamin D deficiency is a global public health issue

Over one billion people in the world are either vitamin D deficient or insufficient, making it a proper global epidemic: current research shows that low vitamin D levels play a role in causing as many as seventeen varieties of cancer, cardiovascular diseases and bone health. Sunlight is the natural way the body was designed to produce vitamin D and you cannot go to toxic levels as the body limits its own production. Vitamin D deficiency is a sunlight deficiency considering most people are indoors almost all the time. Sunbeds were originally invented to trigger vitamin D production in light-deprived Northern European populations, and they continue to provide such benefit.

How much sun exposure is needed to synthesize a sufficient amount of vitamin D?

A well-controlled study[75] with simulated solar UV radiation led to the estimate that about 30 minutes of midday summer sun three times a week in summer clothes would be enough for 90% of the Caucasians to achieve vitamin D levels of above 20 ng/ml at latitudes 30 to 55 degrees. A longer exposure would be needed to achieve desirable levels of 30 to 60 ng/ml, also in other seasons, at earlier or later times of the day, at higher latitudes or for persons with a darker skin colour. Always remember: Never burn! At the first sign, further exposure should be avoided at all cost.

Sunscreen use protects against skin cancer

The use of sunscreen is a key component of public health campaigns for skin cancer prevention, but epidemiological studies have raised doubts on its effectiveness in the general population. A recently published meta-analysis[76] did not show a significant association between skin cancer and sunscreen use. In other words, the results do not confirm the expected protective benefits of sunscreen against skin cancer in the general population.

Furthermore, in a study[77], researchers found that plasma concentrations of four typical ingredients of chemical sunscreen available as over-the-counter product (avobenzone, oxybenzone, octocrylene and ecamsule) exceeded the threshold established by the FDA.

Among 500 couples who were trying to conceive, one study[78] from 2014 found that male partners with higher concentrations of benzophenone-type UV filters had a 30% lower chance of conceiving each menstrual cycle.

06 CONCLUSION

As described in the above chapters of this White Book, moderate exposure to sunlight has many potential health benefits and is important to our well-being. On the other hand, overexposure and sunburn can increase the risk of detrimental effects on the human health.

Unfortunately, public health messages from respective authorities often fail to look at the big picture and don't take the potential positive effects into consideration when giving advice to the population. The concerns about skin cancer, especially melanoma, still dominate the majority of public health campaigns today.

The positive effects of moderate exposure to sunlight on human health, mediated through the synthesis of vitamin D and release of nitric oxide in the skin among many other pathways, are manifold and include decreased risk of certain types of cancers, cardiovascular diseases, diabetes, multiple sclerosis and many more.

For future public health messages that focus on behavior in the sun, it is therefore of crucial importance that sunburn needs to be avoided at all costs as it is the main risk factor for the development of melanoma. When spending longer periods outside, effective protective measures such as wearing clothes combined with seeking shade when the intensity of the sun gets too high, should be recommended. This is especially the case during holidays in a tropical climate to which our skin is not fully adapted.

The difficulty in creating a balanced public health message is that there is no "one size fits all" recommendation possible. It depends on the personal skin type, age, latitude, the time of the year and time of the days, among many other factors how much time can be spent outside in order to obtain a sufficient level of vitamin D before getting a sunburn.

As in many parts of Europe it is impossible to synthesize sufficient vitamin D from the sun during the period from September to March, sunbeds can be a valid alternative when used in moderation. Due to the European standard 60335-2-27 the UV output is limited and does not exceed the intensity of the Mediterranean sun. Further, in a professional studio, the tanning takes place in a controlled environment and customers receive advice from trained staff members that have an extensive knowledge.

In order to keep it as simple as possible while also including the most important facts, authorities should spread a clear message:

Responsible, non-burning UV exposure is a health benefit and should therefore be recommended as such! Sunburns need to be avoided at all costs!

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Boulevard Saint-Michel 65
1040 Brussels, Belgium

Tel.: +32/28810925
Mail: info@europeansunlight.eu
Web: www.europeansunlight.eu