Human skin, aging and antioxidants

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All health care professionals should have basic information about the structure and function of human skin inorder to be able to determine any type of change in normal skin, diagnose present skin problems and prescribe possible treatment for risk factors. Skin is also called the cutaneous membrane or the integumentry system as it has several accessory organs. In adults the skin has a surface area ranging from 1.2 to 2.2 m² and weighs about 5 kg. The skin is about 7% of the total body weight with a thickness of 0.02” to 0.16” range in the average adult. This review of literature covers all the aspects of human skin. Moreover, mechanisms of skin aging are discussed as well as the role of various natural and synthetic antioxidants in protecting skin are covered in this review with sagacity of understanding.

Key words: Skin, antioxidants, aging, vitamins.

INTRODUCTION

It is very important for all health care professionals to have basic information about the structure and function of human skin inorder to be able to determine any type of change in normal skin, diagnose present skin problems and prescribe possible treatment for risk factors (Bianchi and Cameron, 2008). Skin is also called the cutaneous membrane or the integumentry system as it has several accessory organs (Sylvia, 2005). In adults the skin has a surface area ranging from 1.2 to 2.2 m² and weighs about 5 kg. The skin is about 7% of the total body weight with a thickness of 0.02” to 0.16” range in the average adult (Elain, 2005). Skin has two types, hair-bearing skin that covers much of the body and hairless skin as that of palms of hands and soles of feet (John, 1995).

SKIN FUNCTIONAL LAYERS

Mainly the skin is composed of two layers, the epidermis and dermis with a variable third layer, the subcutis or hypodermis (Alan and James, 2005).

Epidermis

Epidermis is the outer, protective and thinner layer of the skin. It is in contact with the outer environment. Sweet glands, hair follicles and other epidermal appendages are laying downgrowth of epidermis. Structurally, the surface of the epidermis is composed of protein plates known as Keratin which forms stratum corneum the superficial tough and water repellent layer (Alan and James, 2005). The epidermis is translucent allowing the light to pass through it. It does not contain any blood vessel getting its nutrients and oxygen from the deep layers of the skin.
Table 1. Nomenclature of the epidermal layers.

<table>
<thead>
<tr>
<th>S/N</th>
<th>English nomenclature</th>
<th>Latin equivalent</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Basal layer</td>
<td>Startum basal or stratum germinativum</td>
</tr>
<tr>
<td>2</td>
<td>Prickle cell layer</td>
<td>Stratum spinosum</td>
</tr>
<tr>
<td>3</td>
<td>Granular layer</td>
<td>Stratum granulosum</td>
</tr>
<tr>
<td>4</td>
<td>Keratin layer</td>
<td>Stratum corneum</td>
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</table>

Traditionally epidermis is considered as stratified squamous epithelium but in fact only the outer three epidermal layers have a squamous configuration while the rest have cuboidal or polyhedral appearance (Alan and James, 2005).

Nomenclature of the epidermal layers

The English nomenclature for the epidermal layers and their Latin equivalent is composed of four layers from bottom to top as shown in Table 1.

In addition to these four layers a fifth layer, the stratum lucidum is also present in the thick skin of sole and palm. This layer has no structural or functional importance and may be an artifact or staining (Alan and James, 2005). Basal layer is also known as the dividing layer of epidermis, attached to a non-cellular basement membrane which separates the epidermis from the dermis. Basal layer have keratinocytes, markel cells and melanocytes. Markel cells have apparent sensory functions and melanocytes produce an important pigment called melanin that protects the human skin against the damaging effect of ultraviolet radiation (UVR) (Desmond, 2005). The cells of the basal layer have no blood vessels so they are not supplied with nutrients and oxygen. Thus, they eventually die and slough off (Sylvia, 2005). Keratinocytes of the basal layers move upwards, lose their nucleus and produce skin protein Keratins and lipids (John, 2000).

Unlike the basal layer, the prickle cell layer is thick of several cells. The cells of stratum spinosum are polyhedral joined by spine-like projections that is why they are referred to as prickle cells (David, 2001). The prickles are joined by Desmosomes to the neighbor’s cells. Prickle cells produce a protein, the cytokeratin which aggregates to form intracellular fibrils called Tonofibrils (Barbara and John, 2005).

Granular layer is the most superficial layer of the non-keratinized part of the epidermis having lost thier nuclei and are distinguished by the presence of dark clups of cytoplasmic materials. It is 1 to 3 cells thick. The cells of stratum granulosum contain a lot of keratohyalin granules hence this layer is called granular layer (Micheal et al., 2003).

Keratin layer is a thick zone of 20 to 30 cells making up to the three-quarters of the epidermal thickness. Keratin inthis layer protects the skin against abrasion. The glycolipid of this layer makes it water-proof. Stratum lucidum layer is a translucent band just above the stratum granulosum. It is composed of few rows of clear dead keratinocytes. It is mostly present in the exposed and abraded areas of the skin such as finger tips, soles and palms. It may be absent in other areas of the skin (Elain, 2005).

Cell types of the epidermis

Cells in the epidermis include keratinocytes, melanocytes, Merkel cells and langerhans cells (Keratinocytes are tightly bound to each other by Desmosomes. They arise from the deepest part of epidermis, the stratum basale by the process of mitosis, they produce the fibrous protein, keratin gives the epidermis the protective property. Body parts subjected to all-time friction have an accelerated production of both keratinocytes and keratin (Elain, 2005). Melanocytes produce melanin which is a pigment that absorbs the ultraviolet radiation (UVR) and thus protects the skin against the damaging effect of UVR. Melanocytes are present in the stratum basale of the epidermis are scattered in the form of dendritic cells. They are present with the keratinocytes in a ratio of 1:4 to 1:10 in various parts of the body. Melanocytes have the capacity to replicate throughout whole life that is why melanin unit of the skin is maintained forever (Micheal et al., 2003).

Merkel cells are scattered very sparsely in the basal layer of epidermis (Barbara and John, 2005). They are mostly present in association with sensory nerves. Combination of sensory nerves and Merkel cells is known as Merkel disc or Merkel's corpuscle functioning as sensory receptor for touch (Elain, 2005). Although Langerhans cells are present in all layers of epidermis but enormous in Prickle cell layer (Stratum spinosum). They have the function of recognizing antigen thus working as a component of immune system. Normally they are present in small number but in case of inflammation/chronic atopic dermatitis Langerhans cells are increased in number (Alan and James, 2005).

Dermis

Dermis is much thicker than the epidermis which may be as thick as 3000 µm. It is largely composed of a protein called Collagen which accounts for 75% of the total...
weight of dermis. Collagen of the dermis is responsible for the elasticity of human skin. Collagen molecules are bound together by elastic fibers made of a protein called Elastin. Dermis also contains glycoprotein responsible for holding a large amount of water. Hyaluronic acid is also present in the dermis which has the ability to attract and hold water (John, 2000). The dermis may be divided into two types, the papillary layer that is very close to the epidermis and the deep reticular layer. The papillary layer has a thin collagen of just 10 mm where as the reticular has collagen of 50 mm. Fibers of smooth muscle are present in the deeper part of the dermis of the penis, scrotum of testes and nipple of breast. Hair follicles, sweat glands and sebaceous glands are present in the dermis (Bradbury, 1975).

Hypodermis/subcutis

It is also known as the subcutaneous fat layer that is connected to the dermis of muscles and bones. It acts as an insulator to store body heat. The subcutaneous fat is arranged into fat lobules keep separated by collagen fibers. When these lobules are extended in length they attain a specific shape called cellulite (John, 2000). The hypodermis may act as food store and shock absorber (Alan and James, 2005).

FUNCTIONS OF SKIN AND ALLIED ORGANS

Skin is the most apparent organ of human body. It is the frontier between the interior and exterior of human body. It protects the body from the pessimistic sway of external environment. The most protective function of the skin is to protect the body from the lethal effects of solar rays. The electromagnetic solar irradiations may be divided into ultra violet (UV) irradiation; visible and infra-red irradiations. Irradiations are further divided into UVB (290 to 320 nm), UVA (230 to 400 nm) and UVC (100 to 290 nm). UVB causes sunburn which results in painful engorgement and erythema of the skin. UVB irradiations are the main cause of skin cancergenesis. UVA irradiations lead to photo (extrinsic) aging (Skin care forum, 2009).

Protection from the environment/ biological barrier

Skin works as a chemical, physical and biological barrier. As a chemical barrier melanin, acid mantle, low pH, the natural antibiotic human defensin and cathelicidin contribute. As a physical barrier keratinized cells mainly contribute. Glycolipid of the epidermis prevents in and out of water and hydrophilic substances (Elain, 2005).

Protection in the form of a barrier

Skin is richly supplied with exteroceptors including
Miessner's corpuscles and Merkel discs. These receptors allow us to feel and create awareness about the touching of our clothes with our skin as well as other irritating chemicals (Elain, 2005).

**Thermoregulation**

During high temperature and exercise our skin cools our body as well as maintains temperature homeostasis because water present in the sweat evaporates (Robert, 2004). In case when the body is too cold it is insulated by the presence of deep adipose tissues preventing heat loss from the body (Barbara and John, 2005).

**Synthesis of vitamin D/ metabolic function**

Vitamin D in the human skin is synthesized in two stages starting with the production of previtamin D after irradiation of 7-dehydrocholesterol by ultraviolet B (UVB) irradiations with wavelength 280 to 315 nm. UVB irradiations struck to the skin cells which isomerise 7-dehydrocholesterol (7DHC) to previtamin D3. Following this initial isomerisation, the previtamin D3 undergoes a heat isomerisation in the skin to Vitamin D3. This process takes several hours (Ann and Ola, 2006).

**SKIN AND AGING**

Like other organs of the human body skin also experiences aging, however as skin is in direct contact with the external environment so aging is a result of environmental damage. The main environmental cause of skin aging is UV irradiations (Fisher et al., 2002).

**Extrinsic aging /photo aging**

Extrinsic aging or photo aging occurs because of external environment particularly solar irradiations. Photo aging has a particular affect on the dermis which results in the changes in the chemical structures of skin proteins, collagen and elastin. Photo aging causes the epidermis to become thick because the quantity of collagen and elastin increases with disorganized structures (John, 2000). Photo aging depends upon the degree and time of sun exposure. People who live outdoor or live in sunny area are more prone to photo aging (Fisher et al., 2002).

**Intrinsic aging/chronological aging**

Skin aging which occurs with the passage of time and which is natural and unavoidable is known as intrinsic or chronological aging. In case of intrinsic aging the skin becomes thinner losing much of its elasticity. In chronological aging epidermis and dermis comes close to each other, dermis becomes wither and the quantity of dermal blood vessels falls down (John, 2000). Chronological aging depends upon the passage of time (Fisher et al., 2002).

**Wrinkle**

Wrinkles are thin furrows in the epidermal layer of the human skin. There are two types of wrinkles: Permanent wrinkles and non-permanent wrinkles. Permanent wrinkles occur at the sun exposed area of the body like face, neck and forehead where as the non-permanent wrinkles occur at the sun protected area of the body like abdomen and back (John, 2000). Comparatively, there is little information regarding the biological features of sun-induced wrinkling, even though it is accepted that this may be due to loss of extracellular matrix, the collagen and fibrin (Rebecca et al., 2001).

**Wrinkles versus age and food intake**

Wrinkles have a positive relation with the age. It has been suggested that taking vegetables, olive oil, fish and legumes, may cause less skin damage. Taking dairy food, butter, margarine and sugar products, may cause more skin damage. The only fatty acid, which has protective effect on the skin wrinkling, is monosaturated fatty acid. More ever retinol, Vitamin C, calcium, phosphorus, magnesium, iron and zinc also have protective effect on skin wrinkling (Martalena et al., 2001).

**Reactive oxygen species (ROS) /oxidizable substrate**

This term is used preferably for oxygen radicals (both free and non-free radicals) or oxidants, which cause oxidation. Examples include superoxide (\(^{\cdot}O_2^-\)), hydroxyl peroxide (\(^{\cdot}OH\)) and HOCl (free radicals) while hydrogen peroxide (\(H_2O_2\)) and singlet oxygen (\(O_2\)) are non-free radical (Barry, 1995). Radiations like UV light, drugs like bleomycin and toxic chemicals like paraquat are the sources of ROS (Minireview, 1997).

**Antioxidants**

This term is used for a substance, which delays or prevents oxidation of oxidizable substrate provided that it should be present at low concentration in comparison to oxidizable substrate. Examples include Vitamin E, Vitamin C, superoxide dismutase, glutathione, β carotenes and polyamines. When reactive oxygen species (ROS) are produced in the body various types of antioxidants...
Table 2. Human skin and vitamins.

<table>
<thead>
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<th>Name of vitamins</th>
<th>Role in skin</th>
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<tbody>
<tr>
<td>Retinoid (Vitamin A)</td>
<td>Decrease sebum production in acne, put on a normal footing the production, of keratinocytes, used in the treatment of photodamage and cellulite.</td>
</tr>
<tr>
<td>Calciferol (Vitamin D)</td>
<td>Downregulate the cutaneous immune system, epithelial propagation and encourage differentiation.</td>
</tr>
<tr>
<td>Ascorbic acid (Vitamin C)</td>
<td>Regulates collagen synthesis, acts as antioxidant and synthesizes lipids of stratum corneum barrier.</td>
</tr>
<tr>
<td>Tocopherol (Vitamin E)</td>
<td>Acts as membrane antioxidant, grants photo protection synergistically with Vitamin C.</td>
</tr>
<tr>
<td>Coenzyme Q</td>
<td>Acts as regenerator of Vitamin E, provides photo protection.</td>
</tr>
</tbody>
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ROS have the potential to react with nucleic acids, carbohydrates and proteins but the more susceptible molecules are polyunsaturated fats, which instigate lipid peroxidation. ROS alter the structures and functions of proteins. They can also modify the individual nucleotide bases; break the single-strand and cross-linkage of nucleic acid (Minireview, 1997).

Mechanism of damage by ROS

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Human skin and vitamins

Table 2 shows the role of various vitamins in the skin described by Stanley and Claude (2001).

Topical vitamin C as antioxidant in skin aging

Chemically, Vitamin C is an alpha ketolactone shown in Figure 1. It is monovalent hydroxyl anion at physiologic pH. It is the main water soluble non enzymatic antioxidant interacting with a variety of free radicals thus providing a front line defense against free radicals. Dermatologically Vitamin C can be used in wound healing, cutaneous aging and prevention of skin cancer. In the past Vitamin C has been marketed in cosmetic industry for the treatment of hyperpigmentation. Vitamin C has the advantage of stimulating dermal fibroblasts for the synthesis of collagen thus preventing photoaging (Roy and Sheldon, 1996).

CONCLUSIONS

Understanding of human skin, skin aging and antioxidants lead to a basic knowledge of preventing various
skin disorders. Sustained disclosure to UV irradiations may contribute to photoaging. From this review we concluded that it refreshes the importance of antioxidants in skin aging and presents new information such as human skin and vitamins especially topical Vitamin C as antioxidant in skin aging. Moreover, mechanisms of skin aging are discussed as well as role of various natural and synthetic antioxidants in protecting skin are covered with sagacity of understanding.

REFERENCES


Figure 1. Chemical structure of Vitamin C.