The impact of 21st century stressors and lifestyle factors on skin ageing

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Skin appearance and health play a significant role in everyone's life and confidence, particularly in today's 21st century lifestyle and the associated stressors promoting skin ageing.

The skin is a dynamic organ, showing apparent signs of ageing and damage, which can be caused by intrinsic and extrinsic factors, with the latter usually accounting for the majority of visible signs [1,2]. Phenotypic, clinical signs of skin ageing include loss of skin tone, elasticity, appearance of fine lines and wrinkles [3].

The increase of life expectancy, in association with age-related diseases, lifestyle habits, and environmental factors have brought to light a synergistic effect on skin health and damage [4]. This article explores the impact of different lifestyle and environmental factors on skin health and skin ageing.

Skin structure

The skin is comprised of three layers: epidermis, dermis and hypodermis (subcutaneous adipose layer) [5]. The epidermis, being the outer layer, is in direct contact with various air pollutants [6].

Underneath the epidermis is the dermis, which acts as a connective tissue, with the dermal-epidermal junction separating the two layers, and is comprised largely of collagen and elastin fibres with the extracellular matrix [3,7].

Lastly, the hypodermis, also known as subcutaneous adipose layer, is the deepest layer of the skin and it consists of subcutaneous fat, connective tissues, blood vessels, larger nerves and macrophages [8]. The hypodermis is mostly comprised of subcutaneous fat, which helps to serve as a thermal barrier, protecting the body from large temperature fluctuations [8].

The skin has a variety of functions, including serving as the body's initial barrier protecting it from pathogens, ultraviolet (UV) light, chemical, as well as preventing water loss from the body and producing vitamin D [3].

UV light

The main and most well-known factor of extrinsic ageing and skin damage is exposure to solar radiation, which includes UV, visible and infrared light, leading to photo-ageing [2,9]. Photo-ageing is fat additional to the usual chronologic skin ageing process, resulting from both acute and chronic exposure to various sources of ultraviolet radiations (e.g. sunlight, tanning beds, etc.) [2].

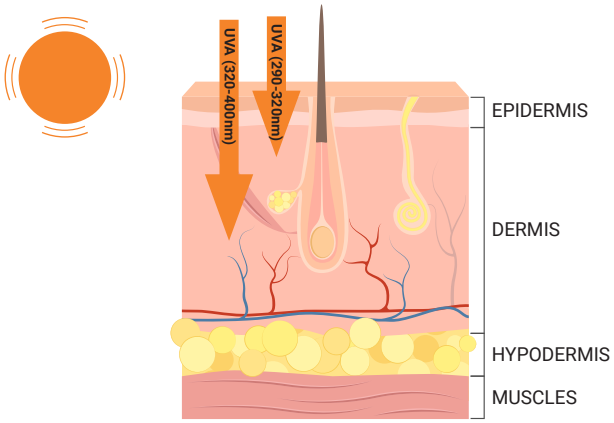

Figure 1: Penetration of ultraviolet radiation to skin's layers.

Exposure to ultraviolet radiation (UVR) promotes oxidative and inflammatory stress within the skin, which can then lead to apoptosis, DNA damage, hyperpigmentation, photo-carcinogenesis, melanogenesis, skin photo-ageing (elastosis) and sunburn [8].

Solar radiation penetrates the skin at various levels [10]. Ultraviolet A (320–400nm) has a deeper penetration to the skin, as it can penetrate up to dermal layer, leading to the development of photo-aged skin. However, the shorter UVB wavelengths (290–320nm) penetrate only to the epidermal layer, and being more highly energetic in nature, they are usually more harmful to the skin (Figure 1) [9].

Among the sources of visible light spectrum, blue light also has a documented effect on skin, as well as circadian rhythm (the body's 24-hour periodic cycle), as studies demonstrate its involvement in deregulation of circadian rhythm by damaging skin cells, inducing hyper-pigmentation and ultimately leading to acceleration of ageing [6,10].

Mitochondrial DNA as a biomarker of skin health

An established biomarker of UVR-induced DNA damage and skin's overall health is the DNA inside the batteries of the cell, namely the mitochondria [7,11]. Several deletions have been identified in mitochondrial DNA (mtDNA) from different ageing tissues, however the most common have been the 4977bp, known as the 'common deletion', a 3895bp deletion and a 6278bp deletion [1,12]. A T414G 'ageing mutation' was identified in skin fibroblasts of older patients (>65 years), but not in younger patients [1,7]. In addition, strand breaks in mtDNA have been linked to various skin stressors [7]. These types of mtDNA damage accumulate differently in the epidermis and dermis, and their associated cell types (keratinocytes and fibroblasts respectively) [13,14].

Pollution

The skin is very susceptible to the effects of external and airborne pollutants [15]. External pollutants, including ozone (O_3) can affect skin homeostasis, leading to the generation of bioactive molecules, e.g. lipid peroxidation, which effect the deeper layer of skin and have been implicated in ageing and inflammatory skin conditions [15-17]. Ozone is considered a strong oxidising agent, able to oxidise components of the cell membrane but as it is filtered out by the earth's atmosphere, it is unable to reach and directly damage live dermal and epidermal cells [17]. Mechanisms associated with adverse effects related to external (air) pollutants, include the generation of free radicals, induction of inflammatory cascade and impairment of the skin barrier [7,15]. The combination of atmospheric pollution and solar radiation can augment these effects on skin, it's microbiome and also

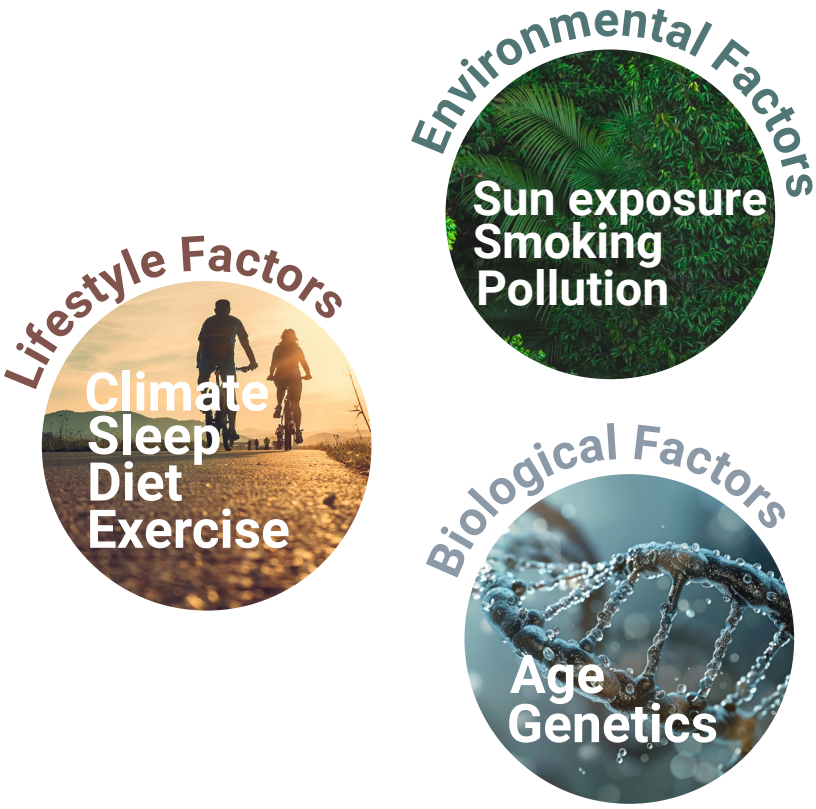

Figure 2: Schematic diagram showing the biological, environmental and lifestyle factors affecting skin health and skin ageing.

the mitochondria [10,18]. More specifically, UVA exposure combined with environmental pollutants (e.g. cigarette smoke) can significantly increase the risk of cancer [4]. Smoking can generate free radicals that can damage skin health and its repair mechanisms, and at the same time can reduce collagen and elastin synthesis [7].

Sleep

Sleep plays an important role in skin health, as it can help with cellular growth and renovation, whereas lack of sleep and poor sleep quality can result in cellular and circadian rhythm disruption [4]. Studies have also correlated the low quality and disrupted sleep with significantly higher incidence of diabetes, obesity and various heart diseases [19]. Lack of sleep can affect the skin barrier and hydration, the elasticity and brightness of the skin, the blood flow, and skin's microbiome [10]. Sleep is directly associated with the circadian rhythm and skin follows a circadian rhythm, where during daytime, it functions to offer the highest skin protection, and highest DNA repair during night-time [6,9]. When skin is exposed to solar UV rays, regulation of cell division takes place via the circadian clockwork, in order to minimise DNA replication, hence protecting the skin against UV-induced DNA damage [15].

Diet and alcohol

Nutrition is one of the most important factors that contribute to our overall health, and there are ongoing novel insights on how diet can influence our skin health, particularly at the molecular level [10]. Over the last decade, there has been heightened interest in the dietary intake of natural antioxidants [8].

Carotenoids have been considered beneficial for skin health, as the carotenoid-rich fruits and vegetables have antioxidant effects and protect against certain diseases. They work in a dose-and-time dependent manner and include pro-vitamin A carotenoids, crocin, curcumin, lycopene, lutein and zeaxanthin [8]. In particular, lycopene, an antioxidant, which can be found in tomato and its derivative products, has been demonstrated to protect the human skin against UVR-induced effects and photo-damage [20]. Increased intake of sugars are linked to glycation in the skin resulting in deterioration and increased rates of ageing.

Insufficient water consumption or water-loss dehydration in the body has been reported to be associated with ageing phenotype and inflammation [8].

Other factors

Genetics, gender and age (biological factors) as well as pigmentation skin type, all play a significant role in skin health protection and skin ageing [10].

Intrinsic ageing (also known as chronological ageing) is an inevitable process and in women there is the additional effects of menopause on skin [3,21]. The skin is a major target of hormones such as oestrogens, androgens and cortisol. Skin menopausal symptoms include dryness, thinning, wrinkles and sagging, reduced wound healing and vascularity [21].

Among the many benefits that exercise can offer, there have been studies showing improved circulation, dermal oxygenation and reduce glycation indexes. However, there is still an opportunity for a series of independent studies showing a clear unequivocal relationship between physical activity and skin ageing [4,22].

Human activities in association with pollution clearly lead to the narrative of climate change development and this also plays a role in skin health. More specifically, the seasonal variations along with the different environmental conditions (humidity, cold temperatures, dry conditions, etc.) in various geographical locations and altitudes, can affect the skin; for example dry environments increase the permeability of epidermis, whereas cold temperatures and dry conditions have a high correlation with irritations of the skin [10].

Conclusion

Biological, environmental and lifestyle factors are the main interacting factors responsible for changes in skin appearance and ageing. Understanding how these different factors affect our skin's health and what can be done to prevent them, can promote and prolong overall skin health and help to counter the skin ageing phenotype.

Measuring mitochondrial damage in skin serves as a highly sensitive and reliable biomarker of skin health. Following exposure to different external and internal stressors, this technology can lead to a more customised skin health approach to the individual, including smart targeting of skin interventions.

The increased dissemination of the knowledge of the effects that these stressors have on our skin will empower the individual with the opportunity to follow and implement healthy skin ageing strategies.

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