Is the Technology Era Aging You? A Review of the Physiologic and Psychologic Toll of Technology Use

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BACKGROUND Technology use is at an all-time high and its potential impact on psychological and physiologic health should be explored.

OBJECTIVE The objective of this narrative review was to identify the role of technology use on health and well-being.

MATERIALS AND METHODS Authors performed a review of PubMed and publications of the World Health Organization, Department of Defense, and Centers for Disease Control and Prevention to determine the impact of technology regarding electromagnetic radiation (EM), posture and mobility, sleep disturbance, and psychological stress and well-being.

RESULTS Studies on the impact of EM were conflicting, with about 45% reporting negative consequences and 55% reporting no effect. Radiofrequency EM (RF-EM) may more significantly affect fibroblasts and immature cells. Device use was implicated in worsening cognitive focus, imbalance, and sleep. Social media use affects self-esteem and mental health and is associated with up to 33% presence of addiction. Effects seem to be dose related and more pronounced in younger ages.

CONCLUSION Technology use significantly affects sleep, mental health, and cognitive function. Seeking psychological help, limiting social media use, and reducing use before sleep may partially mitigate these effects. The impact of EM is undetermined, but the WHO lists RF-EM as a potential carcinogen.

Cell phone and internet use is at an all-time high in the 21st century. Three-fourths of the World's population have a mobile phone subscription and up to 96% of individuals less than 65 years old have a smart phone.[1,2] As the use of cell phones, tablets, WIFI, Bluetooth, zoom calls, and social media have risen, it seems that technology use is inescapable, but is it coming at a cost?

Internet use has been associated with psychological impairment, including addiction, which may be as high as 33% in young adults.[3,4] Internet addiction has gained reputation for causing poor concentration and work performance, increased anxiety and depression, and low-quality sleep.[3,4] Increased stress and decreased sleep have aging effects on the body and skin. But is that all? What about the electromagnetic radiation emitted from our devices—or that is simply "in the air" with the emergence of WIFI, Bluetooth, and satellite signal. New data have shown that electromagnetic radiation may have deleterious effects on the body to include increased production of reactive oxygen species (ROS), impaired reproduction, and compromised repair of DNA.[5,6] Some studies have linked radiofrequency electromagnetic radiation (RF-EM) (100 kHz–300 GHz), a nonionizing form of radiation, to increased risk of brain tumors, leukemia and lymphoma, breast tumors, and testicular cancer.[6–11] Still other studies have linked RF-EM to deleterious in-utero effects on unborn fetuses and changes in hearing in children.[6,7] Electromagnetic radiation is also used in dermatology for tightening and toning the skin. For example, dermatologists use radiofrequency (RF) for tightening effects due to its ability to heat the dermis and stimulate fibroblast production of collagen. The use of high-intensity focused electromagnetic therapy (HIFEM) technology uses magnetic stimulation to increase muscle tone. These dermatologic therapies, however, are short interval exposures and will not be the focus of this review. This review article focuses on the potential risks of chronic device and cell phone use, including its effects on aging. Findings are summarized in Table 1.

What Is Electromagnetic Radiation and How Does It Age Us?

Electromagnetic energy is radiation of different wavelengths ranging from 100 kHz to 300 GHz, which are emitted by various sources of light or devices (Figure 1). Electromagnetic energy can be subdivided into ionizing and nonionizing categories. Ionizing radiation, such as that from x-rays and gamma rays, is more closely linked to cancer and adverse effects. Nonionizing radiation includes ultraviolet radiation, visible light, infrared, microwave, radiofrequency, and extra low-frequency radiation—these come from the sun, electricity, cell phones, tablets, WIFI, Bluetooth, satellites, and more (Figure 1).[8,9] Although nonionizing radiation is thought to be less harmful when it comes to tumorigenesis, recent literature has suggested that it can be harmful to multiple organ systems.

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Electromagnetic Radiation From Our Devices

Extremely Low Frequency: Household Devices and Power Lines

Electromagnetic fields are waves of different lengths, or energies, also called frequencies. Waves with lower energy are called "extremely low frequencies" (ELFs) (0 and 300 Hz). We are exposed in our everyday lives through power lines and household devices (microwaves, hair dryers, toasters).[9] Fortunately, there does not appear to be sufficient evidence to link these waves to health risks, but some studies have potentially linked ELFs to Alzheimer disease and childhood leukemia.[10] Those at most risk of increased exposure to the energy of ELFs are powerline workers. Near these powerlines, humans can experience tingling sensation and even changes to blood chemistry. Overall conclusive evidence is lacking, which limits the World Health Organization's (WHO) ability to offer additional recommendations regarding limiting exposure to ELFs.[8] Ultimately, the exposure to RF-EM is multifactorial—related to exposure time, waveform, temperature, exposure condition, and cell types, among other factors. This makes well designed and controlled studies difficult to achieve and may partially account for the mixed data seen in vivo and in vitro studies.[6]

Radiofrequency Electromagnetic Radiation: Cell Phones, Tablets, WIFI, and Satellites

In 2011, the WHO classified radiofrequency electromagnetic fields as a possible human carcinogen.[7] Radiofrequency electromagnetic radiation is the portion of radiation that is emitted from our devices, Bluetooth, and WIFI (100 kHz to 300 GHz).

Today, there are 8 billion mobile subscriptions worldwide; thus, the potential impact of RF-EM cannot be overlooked.[12] Bluetooth and WIFI have very similar frequencies, ranging from 2.45 GHz (Bluetooth) to 5 GHz (WIFI). Cell phones typically operate from 2 GHz all the way up to 30 to 40 GHz, with higher frequencies used by 5G compared with 2G networks.[13] The designations 2G and 5G are specific to cell phone networks, which use towers with different frequencies to boost their signal and download speed. 2G operates at lower frequencies (800 MHz and 1900 MHz) and was introduced in the 1990s. Now, many cell phones operate on 5G networks, which use 3 different frequency bands operating at low (600–850 MHz), mid (3–6 GHz) and high (20–40 GHz) frequencies. Higher frequencies offer faster download speed but operate at shorter distance; thus, cell phones will use the closest high-speed tower when operating.

Our devices can be harmful both through emission of heat and RF-EM. Direct heat can cause cellular stress and hyperpigmentation of the skin, whereas radiation can penetrate deeply through all layers of the skin, producing ROS and changes in gene expression in keratinocytes, melanocytes, and fibroblasts.[6,7] The WHO has recommended a maximum Specific Absorption Rates, or "SAR," to limit radiation from our devices, which is <1.6 W/Kg in the United States. The average SAR value for cell phone is around 1 W/kg based on holding cell phones 1 cm away from the skin.

Radiofrequency electromagnetic radiation has been controversial in regards to its effects on the human body.[6,14–19] Unfortunately, studies both in the laboratory and in the real world are influenced by confounders—such as background magnetic field exposures, inability to directly measure exposure in the real world, changing technologies over time, and recall bias of affected persons. Further, the impact on human health may be influenced by the signal and heat emitted by radiofrequency and the underlying health of the individual.

Radiofrequency Electromagnetic Radiation: What Do We Know About Its Effects on the Skin?

Radiofrequency Electromagnetic Radiation Affects Metabolism and Antioxidant Activity in Our Skin

Most skin studies on the impacts of RF-EM have focused on human fibroblasts. There have also been in vitro 3D models of the skin in efforts to better characterize the effect of RF-EM on skin structure and function.

Data are mixed regarding the effects of RF-EM on human fibroblasts.[20,21] Radiofrequency electromagnetic radiation may affect gene expression in fibroblasts and alter fibroblast viability and metabolism. This could have deleterious effects on our dermis, including resilience from of stress, wound healing, plumpness of our dermis, and distribution of collagen.

One study exposed human fibroblasts and prostate cancer cells to RF-EM (2.5 GHz, the same as cell phones and WIFI/Bluetooth) for 24, 48, and 72 hours.[20] Fibroblast viability was decreased at all time points and there was a resultant increase in prostate cancer cell growth. A 2020 study comprehensively evaluated the effect of RF-EM on human fibroblasts using high-throughput next-generation sequencing and biomarker analysis.[22] Experiments subjected human fibroblasts to continuous and pulsed signals of 2.45 GHz for 2 hours. There were no significant changes in the different phases of the cell cycle 2 and 24 hours postexposure when compared with control groups. There was also no difference in phosphorylated histones and p53 expression.

Radiofrequency Electromagnetic Radiation Can Affect the Thickness of Our Epidermis and Gene Expression of Keratinocytes

A 2013 Study from the University of Bordeaux Sagalen tested the effects of RF-EM on a 3D model of pigmented skin.[23] They analyzed the expression and markers of keratinocyte and melanocyte differentiation at various timepoints after exposure. There were no changes in the overall architecture of the epidermis, apoptotic cells, induction of p53 expression, or localization of epidermal markers. There were changes in the location of melanocytes

TABLE 1. How Device Use Can Be Harmful to the Body

Physically Harmful	Example	How It Can Be Harmful	What Can We Do to Reduce Our Risk?
Generation of radiofrequency electromagnetic radiation (RF-EM)	Cell phones emit radiofrequency radiation when in use. This includes radiation from WIFI and Bluetooth that use electromagnetic waves to connect to cell phone towers and the internet.	Evidence is inconclusive whether RF-EM is harmful to the body. Some reports suggest that RF-EM may: 1. Cause increased rates of brain tumors, leukemia, and other cancers 2. Cause impaired hearing 3. Harm unborn fetus growth 4. Impair fertility, specifically sperm function	Use cell phones on speaker mode so that the radiation is farther from your body Do not hold cell phones directly to your ear Do not put cell phones in tight fitting pants pocket (this holds it closer to your reproductive organs)
Generation of visible light	Visible light is the portion of electromagnetic waves that we can see. It is generated by the sun and devices like our phone. This is the same as LED lights.	Increases pigment and discoloration in our skin Increases redness in our skin Increases reactive oxygen species which can be harmful to DNA	Consider lowering the brightness on your cell phone Use a tinted sunscreen (tint blocks visible light)
Generation of infrared radiation	Infrared radiation is heat emitted from the sun and devices.	Increases redness in our skin Increases reactive oxygen species that can be harmful to DNA Impaired collagen synthesis and organization	Use skin care products that have antioxidant properties Do not place laptops or cell phones directly on your lap or skin Limit use to <30 min at a time
Carry bacteria and viruses	An average of 68% of cell phones are contaminated with microbes.	Microbes on devices can be transmitted from person to person Microbes on devices can worsen skin conditions such as acne	Regularly wipe down your phone with antimicrobial wipes or cleaners Do not hold the cell phone directly on your skin Wash your hands before you eat or touch your mouth
Psychologically Harmful	**Example**	**How It Can Be harmful**	**What Can We Do to reduce Our Risk?**
Decreased sleep	Cell phone use is linked to poorer sleep	Increased wrinkles Uneven skin tone Increased perceived age	Sleep of 7 h or more was linked to feeling better about one's age and skin compared with sleeping 5 h or less Engage in quiet, reflective time before sleep, instead of using your cell phone More interactive devices (cell phones, computers) impaired sleep more than "passive" devices such as listening to music to watching TV. If you must choose one, consider listening to music before bed Consider taking a melatonin supplement or a cream that contains melatonin
Increased stress	Social media and internet use can increase physical and psychological stress	Dry, flaky skin Poorer wound healing Uneven skin color and texture Increased inflammation in the skin Flaring acne, eczema, and psoriasis	Complete cessation of social media use Engage in meditation or mindfulness exercise Consider professional help, such as cognitive behavioral therapy

TABLE 1. How Device Use Can Be Harmful to the Body *(Continued)*

Psychologically Harmful	Example	How It Can Be harmful	What Can We Do to reduce Our Risk?
Psychiatric disturbance from social media use	Increased depression, anxiety, or body dysmorphia may occur with social media use and the invent of video-based calls/meetings	Seeking more cosmetic treatments Decreased participation in physical activity Impaired relationships at work and at home	Engage in physical activity Take part in activities with others that may not involve technology Consider professional help
Cognitive impairment	Cell phone use can alter one's ability to focus or perform well in school	Poorer performance at work or school Impaired balance Paying less attention to physical triggers for rest, food, and hydration	Take frequent breaks from internet use If you are elderly or poor balance, consider putting the cell phone down while standing Increase awareness to physical cues that your body may be giving you when it is time to rest, eat, or use the bathroom
Internet addiction	Internet addiction can also include social media and online gaming addiction	Compulsatory use of internet use is associated with negative consequences Inability to refrain from internet or social media use Anxiety, OCD, ADHD, and depression may contribute to addictive internet use	Consider getting psychiatric help if you feel that you are addicted to the internet or may have compulsatory behaviors causing you to use the internet more than intended If you feel that your internet use is having negative consequences, consider seeking help from an addiction hotline
Negative impact on childhood development	Children, especially adolescents have poorer sleep, increased stress, and increased psychiatric disturbance associated with internet, gaming, device, and social media use	Poorer quality of sleep in children and adolescents Increased anxiety, depression, and body dysmorphia in teenagers Increased risk of internet addiction in younger aged individuals	Strongly consider limiting access to internet or devices before bedtime Consider limiting/monitoring use in teenagers, as risk for addiction is increased Consider psychiatric help for children or adolescents who display addictive behavior, depression, anxiety, ADHD, or OCD that could be related to or worsening internet use

ADHD, attention-deficit/hyperactivity disorder; OCD, obsessive compulsive disorder.

and their dendrocytic processes. Additionally, loricrin and cytokeratin 14 were significantly decreased at 6 hours postexposure. There was also a decrease of 20S proteasome activity at 24 hours. Authors concluded that 900 MHz RF-EM alters epidermal homeostasis and thus potentially changes the protective capacity of the skin.

Other studies have demonstrated thickened stratum corneum, epidermal atrophy, papillomatosis, hypergranulosis, basal cell proliferation, and impairment in collagen distribution after chronic exposure to RF-EM (900–1800 MHz) in mice.[24–26]

Radiofrequency Electromagnetic Radiation Effects Our Skin Cell's Response to Stress

Studies have showed mixed response regarding genetic expression of heat shock proteins (HSPs) in the skin in response to RF-EM.[25,26]

Sanchez and colleagues demonstrated that RF-EM (900 and 1,800 MHz, similar to 2G and 3G cell phones in the 1990s and 2000s) altered stress response in cultured fibroblasts and keratinocytes.[25,26] Five weeks after exposure to RF-EM, there was elevated HSP expression compared with control groups. There was no marked change in apoptosis of cells or keratinocyte proliferation. Researchers ultimately concluded that the effect of RF-EM was not a significant factor for cellular stress and paled in comparison with that induced by ultraviolet B (UVB) radiation.

Radiofrequency Electromagnetic Radiation Affects Our Hair Cells

Researchers from Turkey published a 2012 study analyzing the effects of RF-EM on hair root cells.[27] They collected hair samples from 8 subjects before and after using a cell phone for 15 and 30 minutes. In hair root cells that were close to mobile phones, there was a significant increase in single-strand DNA breaks. The effect was time-dependent. Interestingly, lower frequencies, such as ELFs, may promote hair growth, thus emphasizing the importance of dose, frequency, and strength on the impact of electromagnetic radiation on the body.[28]

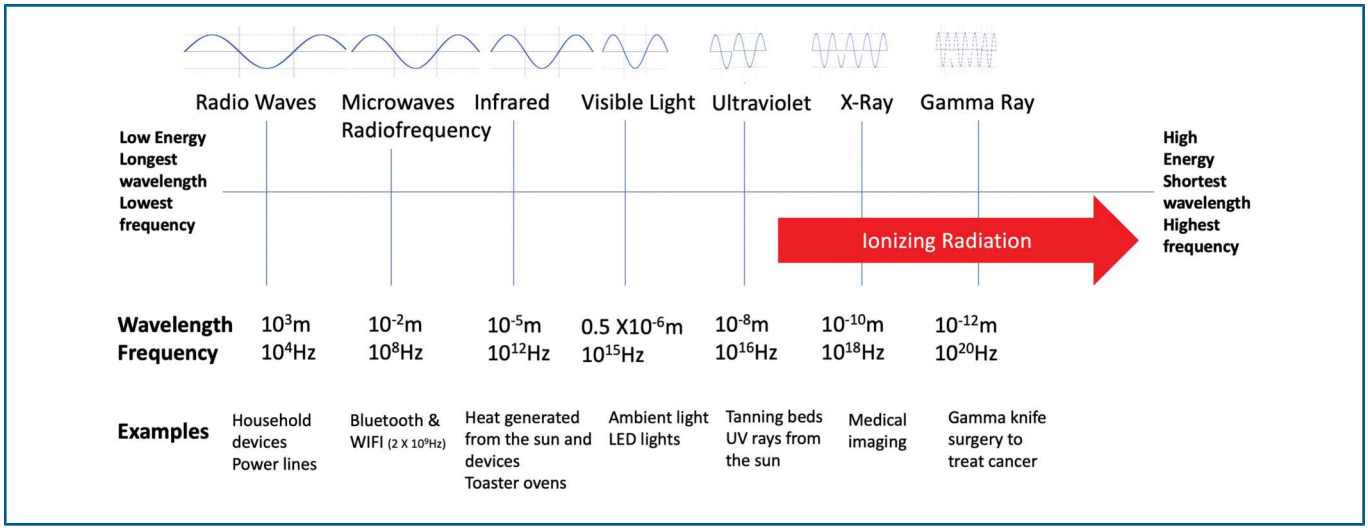

Figure 1. The electromagnetic spectrum.

Radiofrequency Electromagnetic Radiation May Preferentially Effect Faster Growing, Less Differentiated Cells

A meta-analysis was performed of the in vitro effects of RF-EM on human and animal cells. Of the 746 human cell experiments, 45.3% of studies demonstrated a significant effect of RF energy on cells, whereas 54.7% did not (p = .001).[7] Interestingly, when taking into account specific cell types, researchers found that RF-EM may influence the functionality of faster growing, less differentiated cells, such as human spermatozoa and epithelial cells. In contrast, adult glial cells and blood lymphocytes were not significantly affected.

Other Forms of Electromagnetic Radiation From Our Devices: Visible Light, Infrared Radiation

Overview

Of the sun's rays that reach the surface of the Earth, 0.1% is UVB, 5% is UVA, 39% is visible light (VL) (400–700 nm), and 56% is infrared radiation (IR) (700 nm to 1 mm, or 430 THz to 300 GHz). Infrared is energy in the form of heat, thus can be produced by any device or object generating heat. Due to their longer wavelengths, VL and IR penetrate more deeply into, and even beyond, the skin.[29]

Visible Light

Visible light from the sun has been shown to have several deleterious skin effects including impaired response to oxidative damage, altered inflammatory response, increased pigment and poorer hydration.[30]

On a cellular level, experimenters exposed human fibroblasts to electronic device generated light for 1 hour at a distance of 1 cm and measured changes in apoptosis, necrosis, and ROS.[31] After 1 hour of exposure, ROS significantly increased when compared with control groups. The devices used were iphone 8+, iphone 6, and first-generation iPad. Reactive oxygen species increased significantly by 81.71%, 85.79%, and 92.98%, respectively, per device compared with the control groups. There was no significant difference in apoptotic or necrotic cells. They noted that total necrosis was less than 2% for all groups.

Additional research has supported these findings: Hudson and colleagues[32] irradiated dermal fibroblasts and epidermal keratinocytes to UV, VL, and IR radiation. The most significant findings were in dermal fibroblasts, with UV, IR, and VL having additive effects in increasing ROS and inducing mitochondrial and nuclear DNA damage. There was greater damage in fibroblasts when compared with keratinocytes.

Several studies have highlighted the effect of blue light on the skin. Blue light is higher energy light in the VL spectrum (~415 nm) and is more likely to cause pigmentary changes. Blue light mostly comes from the sun, but it is also present in fluorescent lights, LED lights, flat-screen TVs, and computer screens. Blue light causes both immediate and persistent pigment darkening, especially in those with Fitzpatrick Skin Types III and above.[33] In darker skin types, immediate darkening can increase by as much as 15% from baseline, and long-lasting darkness can be up to 50% darker than nonexposed skin.[33–35] One study found that the pigment produced by VL in darker skin types was darker and more long-lasting compared that induced by UVA1.[34] Effects can be seen as long as 3 months after exposure. Blue light may play a role in postinflammatory hyperpigmentation as well, with studies pointing toward potential benefits of sunscreens containing additional VL protection.[34,35]

Overall, the intensity of VL from our devices is far less than that which comes from the sun and exposure time from our devices would need to be much longer to induce pigmentation.[36] For example, Laptops produce visible light about 1,000× less intense than the sun, and cell phones produce visible light that is 700× less intense than the sun. In a study of 12 dark-skinned patients with melasma, investigators exposed a randomly selected half of the face to 30 minutes of blue light

for 5 days in a row, which equated to about 8 hours of exposure to the most powerful of device screens per day. There was no change in lightness, redness, yellowness, or melasma area severity index as measured at Days 1, 5, and 15.

It is also important to note the potential effects of VL (blue light) on aging of the eyes. Almost all visible blue light passes through the cornea and lens and reaches the retina. This light may damage the retina through the production of ROS and could prematurely age the eyes. This could potentiate age-related macular degeneration. Blue light from computer screens and digital devices can decrease contrast leading to digital eyestrain.[37–40] Fatigue, dry eyes, bad lighting, or how you sit in front of the computer can cause eyestrain. Symptoms of eyestrain include sore or irritated eyes and difficulty focusing. Interestingly, a 2018 Cochrane systematic review explored the utility of blue light filtering intra-ocular lenses versus UV-only filtering intraocular lenses and showed that there was no short-term difference in these lenses regarding retina health, daytime alertness, contrast sensitivity, color discrimination, or patient satisfaction. This review suggested that further studies were necessary. Studies have showed mixed results regarding the use of light-filtering spectacles in improving digital eyestrain and retinal health. In general, expert opinions focus on management of symptoms of digital strain, including correction of refractive error and/or presbyopia, treating dry eyes, and incorporating regular screen breaks.

Infrared Radiation and Heat From Our Devices

Infrared radiation accounts for 54.3% of sunlight. It can be felt as any object or device that generates heat. Infrared radiation can penetrate deeply into the body, reaching subcutaneous tissues and is associated with premature aging.[41] The effects of IR on the skin are dependent on intensity, time of exposure, and heat production.[41] In doses less intense than the sun, infrared is marketed for its ability to promote wound healing and reduce inflammation. However, more intense, harmful doses increase ROS and can be harmful to cellular machinery and DNA. Kimeswenger and colleagues[42] exposed melanocytes to both IR and UVR and found that IR may promote survival of melanocytes carrying UVR-induced DNA damage, potentially contributing to the pathogenesis of melanoma. Heat generated from cell phone use may cause similar effects.[41,43] Similarly, varying intensities of LED lights can affect fibroblast gene expression, influencing production of collagen I and collagenase.[44] Likewise, chronic heat exposure from laptops resting on the legs or abdomen has been associated with erythema ab igne, characterized by epidermal atrophy, pigment incontinence, collagen degeneration and dermal elastosis.[45] Other studies have supported these effects of IR on the skin, including upregulated expression of MMP-1, epidermal hyperplasia, increased angiogenesis, erythema, and increased telomerase expression and activity (marker of senescence). It also affects mitochondrial respiratory activity, impacting calcium homeostasis, stress signaling, and apoptosis-related signaling.[46,47]

Regarding heat generated from our devices, most is accounted for by the battery and internal mechanics of the device, with a much smaller proportion of heat generated from RF-EM. A study evaluating the heating effects of cell phones found that the ear increased in temperature more than the cheek after 30 minutes of cell phone exposure (holding the cell phone to the ear).[43] The temperature increased proportionally to time. Heating was only slightly more prominent when RF-EM is present. Fortunately, authors of the Radiofrequency Radiation Dosimetry Handbook from the Defense Technical Information Center of the Department of Defense concluded that even during high power states of RF-EM, the body's thermoregulatory systems (sweating and vasodilation) are able to dissipate heat generated by radiation.[11] When exposed to high-power RF-EM, the body did not exceed 40°C, suggesting a low likelihood of harmful effect from heating.

How Can Technology Use Cause Wrinkles?

Horizontal Neck Lines and Impaired Posture

"Tech neck" is the term used to describe horizontal neck lines that may occur from repeated downward tilting posture of the head when looking at cell phones. The number of young patients reporting with the complaint of horizontal neck lines may be increasing.[48] There have been several proposed treatment options to treat tech neck, including injection of neurotoxin, use of radiofrequency devices, and microfocused ultrasound.[48]

Also, older adults may be negatively affected by cell phone use when it comes to mobility, posture, and balance. Adults over 65 years require increased cognitive workload when using cell phones.[49] Further, the use of cell phones also impairs balance in both elderly and young adults. Elderly adults seem to experience the most mobility impairment during cell phone use, especially when using the dialing function.[50]

Technology Use Effects Quality and Quantity of Sleep

Numerous studies have demonstrated the relationship between technology use and poorer sleep.[51–59] Unfortunately, poorer sleep impairs the body's ability to rest, heal, and repair, including the skin. This can lead to premature aging.

A study of 60 healthy Caucasian women demonstrated that chronic, poor sleep (≤5 hours) is associated with worse skin barrier function, increased signs of facial aging, and worse perception of attractiveness.[51] Even one night of sleep deprivation worsens skin barrier and hydration, pores, brightness, and blood flow.[52] Interestingly, the concept of older perceived age is associated with higher mortality and morbidity.[53] Facial skin aging is the most important parameter for perceived age.

A meta-analysis of the effect of media devices on sleep outcomes evaluated 20 studies regarding the effects of devices on 125,198 children.[57] There was a strong association between bedtime device use and inadequate sleep duration and quality, and daytime sleepiness. Unfortunately, poor sleep can lead to poor diet, obesity, weakened immune system, stunted growth, and mental health conditions. A 2013 survey study of 1,508 Americans demonstrated that 9 of 10 people reported using a device within 1 hour before sleep. Interestingly, the use of more interactive devices (cell phone, computers, laptops, and video games) were associated with increasing reports of difficulties falling asleep and poorer quality of sleep.[58] More interactive devices may impair the necessary and natural withdrawal of the sympathetic nervous system before bed. Watching TV and listening to music may be less stimulating, as they require "passive observation." Also, by keeping cell phones and devices near us while we sleep, we may be awakened by incoming calls or text messages, further impairing sleep.[59]

The effects specifically of RF-EM on quality of sleep have mixed results, with some studies suggesting that RF-EM emitted from base stations, mobile phones, wireless networks, radios, etc may reduce total sleep, increase the time it takes to fall asleep, or influence nighttime awakenings. Other researchers have theorized that RF-EM affects DNA damage and our ability to repair this while we sleep, thus, overall, intrinsically aging humans.

In a recent study, experimenters assigned 31 healthy volunteers to sleep in beds that were insulated against electromagnetic fields.[60] They compared the function of peripheral blood neutrophils and mononuclear cells in the experimental group versus control groups after 2 months of sleeping on their respective (insulated or noninsulated) beds. Experimenters found a statistically significant decrease of pro-inflammatory cytokines (TNF-α and IL-6) after using the insulated bed. There was also in increase of anti-inflammatory cytokines (IL-10). They determined that the biological age of cells decreased significantly after 2 months of using the insulated bed.[60–62] Researchers hypothesized that EMFs impair quality of sleep as well as increase inflammation and senescence in cells. Limitations of the study are small sample size, not taking into account specific lifestyles, environmental factors, or demographics, as well as limited length of the study and inability to determine whether long-term effects are durable, substantial, or truly may increase longevity.

Technology Use Increases Stress

Technology can result in increased stress across multiple domains of life. It can also lead to neglect of other activities, physical symptoms, time pressure, and conflicts of one's personal role in relationships and society.[63] Unfortunately, stress physically ages us as well as worsens cognitive function, increases mind wandering, and decreases the ability to focus. Additionally, increased perceived stress may weaken the immune system and accelerate rate of aging.[64,65]

Stress activates the hypothalamic–pituitary–adrenocortical axis, which also has an aging effect on the skin. The hypothalamus releases corticotrophin-releasing hormone (CRH), which stimulates the pituitary to release proopiomelanocortin (POMC) and its related peptides (α-melanocyte stimulating hormone (α-MSH), beta endorphin, adrenocorticotropic hormone (ACTH). ACTH binds the adrenal cortex, causing it to produce glucocorticoids cortisol and corticosterone, the major stress mediators. Keratinocytes, melanocytes, sebocytes, and mast cells also produce CRH when under stress.[66] Melanocytes and fibroblasts are stimulated locally by CRH, producing ACTH and corticosterone. Unfortunately, these hormones increase inflammation in the skin, stimulate melanocyte proliferation and melanogenesis, and increase sebocytes. There is also local production of epinephrine in the skin. Adrenergic receptors, stimulated by systemic endorphins, and locally produced epinephrine also stimulate melanogenesis and decrease the function of fibroblasts.[66] This results in thicker, darker skin with impaired wound healing and elasticity. Chronic stress, both internally and externally, increases ROS and DNA damage and interferes with the regulation of the cell cycle. Mice studies have shown that repeated short-term stress induces ROS production, upregulates NFKB in the skin and causes depletion of cellular antioxidant machinery.[67,68] Chronic stress as well as psychiatric illness may also shorten telomere length, thus decreasing how many cell cycles a cell can undergo before senescence.[69]

Stress is also a trigger for exacerbation of known skin conditions such as psoriasis, atopic dermatitis, and acne. For example, mice that were subject to overcrowding have increased transepidermal water loss and impaired barrier protection.[70] These all result in skin that is dry, flaky, and wrinkled. Applying ceramides to the skin can partially alleviate this impaired barrier function.

Technology Use May Effect Diet and Hasten the Aging Process

Technology use may lead to decreased physical activity and neglect of bodily signals of needs for food, drinks, or break. Unfortunately, this can lead to poorer diet choices in addition to physical stress. Diet is an important factor in skin aging. A systematic review highlighted the association of poorer diet with shortened telomere length (increased risk of chronic disease and mortality).[71] Diets rich in fruits and vegetables, including the Mediterranean diet, were associated with longer telomeres. Further, diets high in sugar can elevate blood glucose, leading to accumulation of advanced glycation end products, which damages collagen and elastin in the tissue by crosslinking their fibers.[72] This leads to sagging, wrinkled skin.

Technology Can Be Associated With Psychological Disturbance

Between the years 2018 to 2019, more than 280 million people joined social media worldwide, and more than 360 million came on the internet for the first time.[73] Unfortunately, internet use can come with significant consequences, such as

addiction, obsessive–compulsive disorder, ADHD, anxiety and depression.[74] A recent 2018 study determined the relative risks of internet-related addictions and mood disturbances among US college students compared with students across 7 Asian regions.[3] Of the 8,067 college students who completed the survey, there was a prevalence of 8.9% for Internet addiction, 19% for online gaming addition, and 3.1% for online social networking addiction. Compared with US students, Asian students had a higher risk of online social networking addiction, and higher rates of internet addiction as well as depression. In the United States, anxiety was more common. A 2016 study of 23,533 adults found that addictive technology use was associated with younger demographic and psychiatric disorders such as obsessive compulsive disorder (OCD), attention-deficit/hyperactivity disorder (ADHD), depression, and anxiety.[75] Authors suggested that underlying risk factors such as mental health disorders and younger age may inherently be tied to more compulsatory internet use.

Further, technology use may be associated with reduced satisfaction with body image. A recent cross-sectional study of 1,010 subjects based out of Saudi Arabia suggested that body dysmorphic disorder was significantly associated with more time spent on Instagram and Snapchat.[76] The highest concerns were skin disfigurements (acne, scars, wrinkles, paleness, and redness) and hair issues. Thirty percent reported a concomitant diagnosis of psychiatric problems. Most participants spent over 4 hours per day on social media. A 2017 American Academy of Facial Plastic and Reconstructive Surgery supports these findings. A survey found that 55% of surgeons reported seeing patients who wanted to undergo surgery to improve their appearance in selfies.[77] Unfortunately, this also occurs at a young age.[78] Another recent 2018 population-based survey of 252 participants measured participant's personal feelings of self-esteem and self-worth, as well as acceptance of cosmetic surgery related to their social media use.[79] Lowest self-esteem was reported among users of YouTube, WhatsApp, VSCO (photo and video editing app), and Photoshop.

Discussion

Exposure to devices and technology in our everyday lives may have detrimental effects on aging. Below is a brief summary of ways to mitigate these potential effects, with details explanations available in Table 1.

Radiofrequency Electromagnetic Radiation

Exposure to RF-EM emitted from our devices and WIFI is multifactorial—related to exposure time, waveform, temperature, exposure condition, and cell types, among other factors. This makes well designed and controlled studies difficult achieve and may partially account for the mixed data seen in vivo and in vitro studies.[6] Ultimately, evidence is inconclusive regarding the effects of RF-EM on our bodies, but there is enough evidence of potential harmful effects on the brain (increased tumorigenesis), sperm (decreased sperm viability and function), and potential antioxidant machinery within fibroblasts. Radiofrequency electromagnetic radiation induced alterations in stress response of epidermal and dermal cells may be implicated in premature aging of the skin. Thus, the WHO has classified RF-EM as a potential carcinogen. Ways to reduce our exposure include limiting time on our cell phones, using our cell phones or devices on speaker mode rather than directly to our ear, and not holding cell phones in our pockets close to reproductive organs.

Visible Light and Infrared Radiation

Visible light and infrared radiation radiating from the sun are more harmful than that from our devices given significantly increased intensity.[36] Fortunately, studies have shown that VL from our devices does not necessarily worsen pigmentation in all skin types; however, darker skin types still tend to be more at risk of pigmentary alteration from VL.

Broad-spectrum sunscreen blocks 90% of rays with wavelengths <370 nm. However, this does not protect from VL. Iron oxide is a metal oxide that can scatter, absorb, and reflect VL. "Tinted" sunscreen products and concealers may contain iron oxide (in the inactive ingredient list).[35] Sunscreens protecting against UV as well as VL were more effective in treating melasma as well as preventing melasma relapses than sunscreen protecting against UV alone.[34]

Posture and Neck Wrinkles

Our physical posture and holding of cell phones can have significant impact on skin wrinkles. Tilting of our head while looking at cell phones can increase horizontal neck lines and also impair balance and cognitive work load. This may be amplified in elderly patients. We can mitigate some of these potential effects by limiting use of devices while standing or walking.

Sleep

Numerous studies have supported the negative impact of device use on sleep. Unfortunately, poor sleep can lead to increased morbidity and mortality related to diet, cognitive function, immune health, and overall longevity. People less than 30 years are more likely to use cell phones before sleep, with these more interactive devices causing worse impairment in sleep onset. Potential ways to mitigate these effects are to limit device use at least 1 hour before sleep, engage children in bedtime routines with quiet activity without the use of devices, and potentially use "less" interactive devices such as watching TV or music. Users can also silence their phone at night to limit incoming text messages or alerts from disrupting sleep.

Stress and Mental Health

Internet use, specifically social media, can increase stress, resulting in premature aging and increased morbidity and mortality. Further, stress increases cortisol and epinephrine in the skin, leading to increased wrinkles, dyspigmentation, and impaired immune function. Studies also support the connection between social media use and low self-esteem,

body dysmorphia, depression, anxiety, and compulsive behaviors. Those who are younger or have psychiatric diagnoses may be at increased risk of psychologic impairment from social media use. Users of social media are also more likely to seek out cosmetic procedures to improve their appearance in "selfies" and on screen.

To mitigate these effects, it is important to engage in social activities or support groups that do not include devices, seek professional help of a psychiatrist when necessary, and engage parents in dialogue with their children regarding body positivity, expectations, and norms.

Limitations

Data regarding the effects of technology use on the human body are varied and conflicting. Further, end points are varied across studies and there is difficulty in accounting for variables such as different lifestyles, environmental factors, and demographics. In sum, it is difficult to draw clear conclusions regarding the short- and long-term effects of technology use in humans.

Conclusion

Technology use is increasing with over two-thirds of the world "online." We cannot underestimate the potential risks of technology and device use, although studies regarding causality are lacking. It seems that the most significant impact of device use is on mental health and sleep, whereas there are limited data on the impacts of radiation from our devices and household items on our bodies. Studies on electromagnetic radiation are often nonstandardized in methodology due to difficulty controlling all parameters of radiation, especially in epidemiological studies where exposure and demographics are varied. Further, in vitro and in vivo studies of impact of RF-EM, VL, and IR are also mixed; however, electromagnetic radiation coming from the sun is significantly more intense than that which is emitted from our devices and likely to be more harmful. It is important to limit device use before bedtime in both children and adults, as well as seek appropriate psychiatric help if depression, anxiety, or compulsive tendencies are identified.

Future Directions

The potential harm of daily device use warrants additional studies to explore long-term effects. Harmful effects seem to be dose and time dependent, and this is especially relevant now that devices are being used as early as infancy and more education and work is being done on electronic devices than ever before. We may not yet know the long-term cumulative effects of RF-EM, VL, and IR from our devices because they have rapidly entered day-to-day life in a short period.

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