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A Narrative Review on the Role of Technology and Nutrients in Ocular Health

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The COVID-19 pandemic has led to a revolution in the education sector. The continuous use of gadgets for learning and entertainment has aroused a keen interest in eye health and the role of foods and nutrients in improving eye health. This study aims to identify and summarize various eye disorders and parameters that are involved in ocular health. Methods: A detailed search of related literature has been carried out with the help of authenticated search engines like Pubmed and Google scholar to review the major deleterious eye problems that persist, and the aetiology of the disorders. Though ocular health is determined by several parameters like socio economic factors, genetic determinants, gender, race, life style and nutrition, diet seems to be a significant lifestyle element that pose to have longstanding effects on ocular health. This study concludes that, it is not an individual nutrient or non-nutrient that impacts eye health, rather a holistic nutritional approach renders more efficacy on vision. It is emphasized that a proper advocacy of foods and nutrients, wise means of technology usage can help to overcome the deleterious effects of deficiencies on eyes.

Keywords: Age related ocular health; Eye health; Nutrients; Technology; Vision.

Vision being the most prioritized of all human senses, eye health is a universal health priority, transmuting lives of people of all ages from all socio economic groups. Eye health is defined as "maximised vision, ocular health, and functional ability", which is essential for being productive in daily life, improved educational outcomes, being inclusive and acceptable in the society, complete healthy outfit, self-confidence and quality living[1]. Weakened eye health and vision pose a deleterious outcome on quality of life and confine a person to a narrow zone by reducing mobility, affecting mental health, increasing falls and accidents, and also influence financially. Therefore, it is imperative that poor ocular health needs to be viewed as a health issue with more prominence. The eye, is a complex structure linked with adnexal tissues, and visual pathways within the brain and structural and physiological integrity of these organs are essential to attain a clear vision. The cornea and lens, the front parts of the eye focus light onto retinal photoreceptors and transform light stimuli to neuronal impulses with which a 3D image is created by the brain. Commotion in this pathway causes vision impairment.

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The threats posed by the Covid-19 pandemic in the arenas of education, economy, food and nutrition security, physical and mental health has led to many innovations and digitalization. Though digitalization has contributed enormously during the pandemic to the education sector, in bridging the lacunae of offline education, the continuous use of gadgets and always being online have curtailed the children to a particular place through the day, has impaired the mental health, physical health, specifically the vision. Recent statistics has shown a drastic increase in sale of digital devices like smart phones and laptops during the pandemic. The previous reviews have studied the influence of any one of the parameters on ocular health, while, the objective of this review is:

To summarize the collective sway of technology on eye health, the role of foods and nutrients on common eye ailments and the impact of other external factors that contribute to poor eye health.

METHODOLOGY

The relevant literatures for this review article has been sourced from recent studies, research and review articles published between the years 2017-2022 from search engines like Pubmed and google scholar on the basis of their mention or discussion on the keywords or search terms used for this study. Figure 1 illustrates the process of literature search.

RESULTS AND DISCUSSION

The outcomes of the search pertaining to the study is presented in this section under the following headings in par with the stated objective:

Impact of Technology on Eye Health

Science, is always a double edged knife with boon and bane. Though, the use of digital gadgets is on the rise in recent years among people of all-age groups, the percent of users and the time of usage is on steep rise due to the Covid-19 pandemic since 2020. The school aged children are forced to attend classes through online mode either by using mobile or computers, while for the elderly, the curfew has restricted the social life addicting them to digital devices, leading to Digital Eye Strain. Digital Eye Strain manifests as dry eyes, headache, blur in vision, or pain in shoulder and neck. Although, the prevalence of Digital Eye Strain, is less focused in India, so far and blooming only now on, while in the West, DES in form of dry eye disease, was found to be prevalent at the rate of 49.5% in 2016 itself . Table 1 depicts the impact

Table 1. Impact of digital devices on eye health

Symptoms of digital eye strain	Prevalence rate
Coloured rings around bright objects	4.9 %
Double vision	5.7%
Blurring of vision	16.5%
Difficulty in focusing printed text	17%
Excessive blinking	18.7%
Itching	18.9%
Sensitivity to light	21.6%
Dryness of eyes	22.4%
Burning of eyes	22.9%
Watering of eyes	23.1%
Redness of eyes	23.1%
Heavy eyelids	23.8%
Eye pain	29%
Headache	43.5%

Source: Indian Journal of Ophthalmology: November 2020

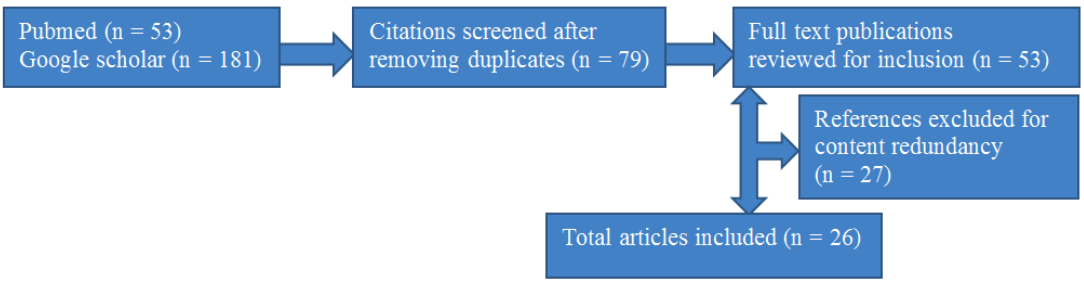

Fig. 1. Flowchart depicting literature selection process

of digital devices on eye health especially during the pandemic curfew as per the study by Bahkir et al., [2]

The impact of technology on ocular health is reversible to a great extent by following 20:20:20 rule, which advocates a screen time of 20 minutes, followed by 20 seconds focusing at an object 20 feet away as depicted in figure 2. Similar to this rule, use of eye drops, changing the gadget settings, by increasing font size, use of anti-glare screens, use of right screen contrast and regular eye check-ups are aids to maintain eye health in this tech-savvy era.

Impact of Nutrients on Eye Health

Age Related Macular Degeneration (AMD)

Age-related macular degeneration in old age, causes loss of vision due to macular damage, the part of retina of the eye that controls sharp, straight-ahead vision. Contemporary studies appreciate the significance of the balanced whole diet, rather than the specific nutrients and antioxidants and this has paved way to study the roles of macronutrients too in the Age-related macular degeneration. The liaison between the risk for AMD and carbohydrate or dietary fat encompasses both the quantity and quality of the macronutrient. Let us review the impact of each one of the dietary fats including omega-3 and omega -6 fats, mono and polyunsaturated fats(MUFA, PUFA), saturated fats, total fats, trans fats and cholesterol as well as their food sources on the risk for Age-related macular degeneration.

Literature states that increased consumption of omega-3 fats, specifically long-chain fats like docosahexaenoic acid DHA) and eicosapentaenoic acid (EPA) found chiefly in fish, have been linked with betterment of various chronic diseases, including AMD. Cross-sectional analyses indicated that the intake of at least two servings of fish (in any form, baked or broiled fish or oily fish) in a week was associated with decreased risk for neovascular Age-related macular degeneration (abnormal blood vessels growing underneath the retina) when compared with non-consumers of fish. Nuts being a rich source of PUFA, both omega-3 and omega-6 fatty acids it was found that 1–2 servings of nuts in a week decreased risk of early Age-related macular degeneration The consumption of low fat dairy foods decreased the risk of AMD and also the investigation into relationships between intake of animal and vegetable fat, specifically trans-fat, and cholesterol, has proved an increased risk for Age-related macular degeneration. However, the influence of MUFA and saturated fats intake on Age-related macular degeneration risk is vague.

It is also to be noted that consumption of high glycaemic foods like refined carbohydrates and sugars cause glycoxidative stress that leads to accrual of high levels of intracellular glycated proteins and partial protein editing capacities, which proceeds to a vicious series of glycative damage, weakened proteolytic capacity, and build-up of glycated proteins, cytotoxicity and tissue dysfunction.[3] In an animal study high fat and high sugar diet with soda-like drinks induced more severe Age-related macular degeneration features while in contrary AMD features were ameliorated with low glycemic diet.

The pigments are potent antioxidants. Impact of certain flavonoids are shown in table-2. Lycopene most commonly found in tomatoes mark for a prospective role in retinal health. It was found that serum lycopene, Low Density Lipoprotein, and High Density Lipoprotein levels of AMD patients was less, than the healthy controls. Anthocyanins, red–purple pigments are strong antioxidants and are major components in the red, blue, and purple colouring of flowers, fruits, and vegetables. Fruits like blueberry, black berry, red grapes, pomegranate, blackcurrant, strawberry, are rich sources of anthocyanins. A protective effect of anthocyanins and xanthophylls was found on UVB-induced damage in retinal pigment epithelial cells.[4] Also it was found that a high intake of xanthophyll-containing foods like cooked egg yolk, vegetables, and spirulina, are effective in treatment and prevention of macular degeneration and eye-related disease. A daily dose of 10mg of lutein and 2mg of zeaxanthin from foods like kale, maize and avocado aids to prevent AMD in the elderly[5]. Studies have also revealed that the maternal nutritional status of lutein and zeaxanthin influences the visual acuity of offsprings.[6] However, the supplemental studies on lutein efficacy on eye health have been for a shorter period (less than an year), long term studies would provide more authenticity[7]. A reduced likelihood of neovascular in subjects reporting high intakes of â-carotene (green leafy vegetables, yellow, red and orange coloured fruits

and vegetables) vitamin C (citrus fruits, amla, guava, capsicum), and vitamin E (vegetable oils, sunflower seeds, green leafy vegetables) is revealed. It is also evident that 80 mg/day of zinc reduced the risk of progression of neovascular AMD[8]. Age-Related Eye Disease Study concluded that supplementation with 500 mg of vitamin C, 400 IU of vitamin E, 15mg of beta-carotene, 80 mg of zinc as zinc oxide, and 2 mg of copper as cupric oxide reduced the progression to late-stage AMD from 28% (observed with placebo) to 20% at 5 years, in people with at least intermediate AMD. A similar review states that people with AMD may experience some delay in progression of the disease with multivitamin antioxidant vitamin and mineral supplementation over a period of 6 month to five years. Zinc as an indispensable antioxidant proves potent in prevention of AMD, cataract and diabetic retinopathy too. In animal models Retinal ganglion (nerve) cell death induced retinal dysfunction has been counteracted by supplementation with spearmint extract, forskolin, B vitamins and homotaurine.[9] Nevertheless, any natural food with the antioxidant, anti-inflammatory and anti-apoptopic properties have proven to prevent nerve cell degeneration and improve visual health.[10]

Fig. 2. Strategy to prevent Digital Eye Strain

Source: Laser eye surgery of Erie, 2020

Table 2. Impact of nutrients on eye function

Nutrient	Dosage	Food source	Impact on eye health
Epigallo catechin gallate	200 mg/day	Green tea	Improves central retinal function
Diosmin	300 mg/day		Improves retinal sensitivity
Proanthocyanidins	150mg/day	Grape seed	Improves hard exudate severity & Decreases total macular volume
Anthocyanins	50mg/day	Pomegranate, berries, red grapes, tomatoes, red beans. (Red coloured food sources)	Increases retinal blood flowImproves ocular blood circulationImproves tear secretion volumeImproves visual acuity visual field
Genistein	80mg/day	Soy bean	Improves central retinal activity
Vitamin E	5 mg/day	Nuts, seeds, greens, vegetable oil and wheat germ oil	Improves central retinal activity
Vitamin C	30 mg/day	Citrus fruits, bell pepper	Improves central retinal activity

Source: Frontiers in Nutrition, 2021

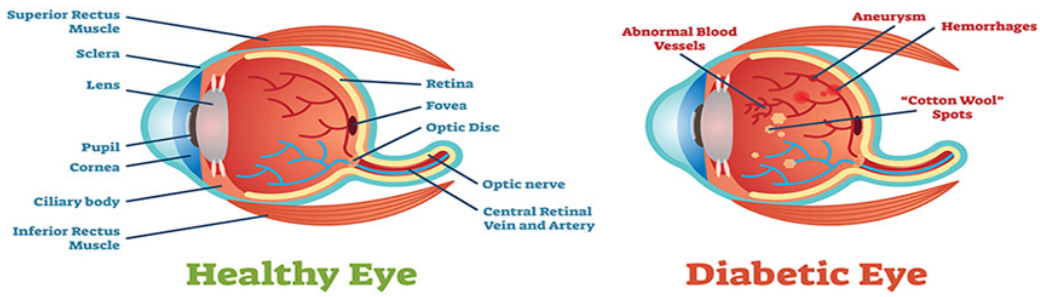

Fig. 3. A Comparative figure on normal and diabetic eye
Source: American Optometric Association

Cataract

Cataract is a visible opacity which has impaired over 60 million people globally. Diabetes increases the risk for cataracts. As diabetes mellitus can be managed through proper dietary modifications, the progression of cataract can be related to diet too. Though aging is a predominant causative factor, the oxidation occurring within the lens can be significantly prevented or the progression can be slowed down by regular consumption of antioxidant nutrients or with the help of a wholesome diet that contains ideal, required levels of vitamins C, E, and forms of the carotenoids viz. lutein and zeaxanthin, and the regular use of multivitamin supplements. A study of baseline factors that predicted cataract in the AREDS (Age Related Eye Disease Study) group found reduced risk of developing nuclear cataracts over a follow-up period (10 years), with the use of multivitamins supplements[11]. In general, the literature suggests diets high in fruit and vegetables reduced the incidence of cataracts by 62%, while 4-6 mg of zeaxanthin and lutein per day in diets lower incidence of nuclear cataracts by 23%, 250mg of Vitamin C/day, and multi nutrients supplements (vitamins-minerals) are allied with dwindled disease rates.[12] It is to be noted supplementary Vitamin E and dietary Vitamin E reduced the prevalence of cataracts by 10% and 80% respectively. The Healthy Eating Index and Mediterranean diet has also been appraised as a potent dietary pattern for deterrence from cataract.

Diabetic Retinopathy and Neuropathy

Diabetic retinopathy, as the name goes is a micro vascular complication of diabetes allied with age of onset of diabetes, extent of diabetes, and poor control of blood sugar levels. Diabetic retinopathy is first diagnosed by the presence of micro aneurysms, the early detection of which will prevent severe vision loss in diabetics[13]. As known, the relationship amongst nutrients, type of food, and dietary patterns in the maintenance of blood sugar levels is strong in comparison to any other diseases. Treatments that regulate and control diabetes lower the headway to diabetic retinopathy.[14, 15] Figure 3 depicts the impact of diabetes on eye health. Clinical trials with flavonoids supplementation is an economical and effective means to prevent diabetic retinopathy.[16]

It is understood that in animals, intermittent fasting improves retinal ganglion cell survival subjected to ischemia, restructures the gut microbiota by modulating the production of neuroprotective bile acids, thereby preventing diabetic retinopathy.[17] However more studies are needed to substantiate this theory.

Nutritional Optic neuropathy, a condition found to prevail more on vegan subjects, can be reversed on supplementation with B-complex vitamins (thiamine, cobalamine, folic acid) and copper.[18]

Dry Eye Disease

Dry eye disease or Ocular surface disease is a "multifactorial disease of the tear film and ocular surface that results in symptoms of discomfort, visual disturbance and tears film instability with potential damage to the ocular surface". Dietary supplementation of omega-3

fatty acids, Preformed GLA present in green leafy vegetables, nuts, vegetable oils (evening primrose, blackcurrant seed , borage and hemp seed) , and from spirulina, cyanobacteria when taken in prescribed amounts in daily diet helps to prevent dry eye symptoms. Vitamin A, Vitamin D and Lipoic acid also protects eyes from damages due to dry eyes[19]. Of all nutrients or nutraceuticals, the role of omega 3 fatty acids on ocular surface disease prevention is strongly exhibited. However, the frequency of consumption and dosage levels need further researches[20].

Anaemic Retinopathy

The importance of iron in overall well-being cannot be underrated. This holds good for eye health too. Anaemia, the condition when the level of haemoglobin in blood falls below 6 gm/dL has been observed to cause retinopathy, especially when coexists with thrombocytopenia approximately in 28% of the population. The risk of retinopathy is directly proportional to severity of anaemia. Anaemia causes retinal hypoxia, which hints to vascular dilatation, higher transmural pressure due to hypoproteinemia, and micro traumas to the vessel walls, retinal oedema and hemorrhages infarction of the nerve fiber layer which clinically displays as roth spots. Other manifestations include venous stasis, angiospasm, increased blood viscosity and hypotension leading to optic neuropathy. Treatment and recovery from anaemia resolved roth spots.[21] Iron, folic acid and vitamin B12 rich foods like organ meat, sea foods, dry fruits, green leafy vegetables, and dairy foods help to overcome the deficiency. In severe cases of anaemia blood transfusion is recommended.

External Factors influencing eye health

The prevalence and roots of eye diseases are voluminous and the jeopardy factors and disease-specific trends are on continuous change. Specifically, in school going and early adult population, the alterations in environment and change in the educational system is believed to be a predominant cause for increase in short-sightedness. While, in late adults and geriatrics, mechanised sedentary life style, and poor quality of diet are known to be contributing factors for non-communicable diseases, which in turn cause cataract, diabetic retinopathy and so on.

The socioeconomic milieu of a child will profoundly influence the health of eyes health in due course of life, along with the mother's nutriture, mother's life style (smoking and consumption of alcohol) and vaccination status. Some of the pre-natal infections (Zika, Toxoplasmosis, Rubella and Syphilis), pre-term birth, low birth weight, also determine eye health of an individual.[22] All these impediments may progress to retinopathy of prematurity and cerebral visual impairment.

Visual function is also determined biologically i.e. eye disorders often have genetic association. Together, social and hereditary causes govern functioning and health of the eye. For instance, retinoblastoma (eye cancer in childhood), is an inherited condition, yet, socio-economic and ethnic features influence access and viability to the treatment, thus facilitating in vision and survival.[23]

Though, the process of eye development and eye function starts in conception the rapid vision development occurs after birth and fullest development is attained at around eight years of age. The early childhood period is crucial for overall growth and development as onset of any sort of vision damage, during this life stage cause delay in psychological, neuro-motor and cognitive development. Moreover, lack in visual stimulus between birth and eight years of age can lead to amblyopia, a permanent vision damage. Between childhood and adolescence, when the eyes grow and change shape, the genetic factors and environmental factors like exposure to sunlight, outdoor activity, nutritional status and screen time, can affect eye health. Several childhood infectious diseases viz. trachoma, toxoplasmosis and onchocerciasis due to accrued pathology can lead to vision impairment latter life.

The age-related visual impairments like presbyopia starts developing from the age of thirty-five, due to the aging of lens, while certain conditions (eg, glaucoma and age-related macular degeneration) have a multifaceted epidemiology, which can network with food and other genetic factors [24].

Manifold societal and life style determinants (diet, activity, obesity) cause diabetes and in turn diabetic retinopathy. Whereas, cataract arises from ageing of lens that occurs due to exposure to ultraviolet light, poor nutriture, lack of fluids, diabetes and smoking.

The path of visual function in life stages is not static. The risk factors are compliant to different

intervention strategies, like social determinants, wherein a continuum of promotion, prevention, treatment, and rehabilitation procedures are needed. Though the issues are complex, requiring multi-sectoral tactics like a balanced diet, proper housing and sanitation, social security, and health education, long-term health schemes by the government and investment in the health system would promise the attainment of better health equity[25].

It should also be understood that in certain individuals visual impairment is also allied to genetic makeup.[26]

Gaps and Recommendations

Studies on public health and clinical trials need to be expanded. Awareness should be created on the relationship between optimal health, the wise use of technology, and lessened vision syndromes, particularly while aging. The boon of telemedicine, which bloomed during the pandemic, should be extended to remote areas to educate people on how to manage metabolic disorders like obesity, and diabetes and their impact on retinal diseases like diabetic retinopathy and AMD, and also to adhere to rules while using gadgets. Long-term nutrient supplemental studies should be carried out to evaluate the impact of food and nutrients in subjects with familial history or who are vulnerable to chronic retinal diseases like retinal degenerative disease, atrophic AMD, and aging retina. Above all, measures to decipher the developments in clinical trials into clinical practices, to lessen the possibility of avertible vision loss and functional significances of visual impairment is found to be lacunae and such research studies are highly acclaimed.

CONCLUSION

To conclude, poor eye health due to overuse of gadgets, poor nutrition or genetic and environmental factors can be distressing to the individual because of its harmful impact quality living. Though the genesis of these disease conditions cannot be completely understood, to an extent, it can be alleviated by factors like nutritious diet, healthy life style and following technical guidance. Though certain nutrients have a commendable role in nurturing eye health it is evidenced that a single nutrient cannot transform, rather it is combination of nutrients or a balanced diet can improve the bioavailability of nutrients and enhance the eye health. As, the influence of nutrition in vision and eye health remains to be perplexing, the scope for future research to augment the role of nutritional strategies for boosting eye health is promising and is the need of the hour, hence greatly recommended.

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Conflict of Interest

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