The Impact behind Myopia

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Abstract

Myopia is been rated the most common eye condition worldwide, yet many people are still misinformed about it. To get a better understanding of this refractive error, knowing the definition is a key point, just as much as knowing that myopic levels has been unceasingly rising over the years, and are expected to continue this path. Exploring different influential factors that contribute to nearsightedness origin and looking at the biology overview of a myopic eye compared to a normal eye's function can vastly facilitate the understanding of the subject, especially in today's world where myopes are treated differently than they were decades ago.

Keywords: myopia, refractive error, ophthalmology, hyperopia, astigmatism, mendelian randomization, population genetics.

The Impact behind Myopia

Nearsightedness is the most common eye condition around the world, yet many people are still misinformed about it. This condition present in our everyday life, even when not considered fatal, can affect both the myope as well as the people around, and in some cases future generations.

Definition of Myopia

Myopia has been defined in many ways with different terms; it has been described as an "eye condition," a "visual impairment," a "disorder," and even a "type of refractive error". Overall myopia is mostly known for its most common name "nearsightedness." It has been ranked as a global concern since it has reached the top causes of visual impairment worldwide (Hornbeak & Young, 2009). If detected early, myopia can be treated with corrective lenses, if not it could increase an individual's health risk leading to headaches, eyestrain, or severe visual impairment (U.S National Library of Medicine, 2020).

The Biology of a Myope's Eye

Human eyes function through a process that starts with the refraction of light from an object. After the light enters the eyes through the cornea and the pupil (which is shaped by the iris), it passes through the lens that adapt to focus either on distant or close objects. After the light reaches the retina, the signal is sent through the optic nerve to the brain where the images are processed. When it comes to a myopic eye, two complications can manifest. Either the cornea or lens are not shaped properly (refractive myopia), or the eyeball is too long (axial myopia). When the light enters a misshaped cornea or lens, less light is projected towards the retina sending an incomplete signal to the brain and translating the signal incorrectly generating blurriness. On the other hand, when the eye is too elongated, the distance between the cornea and

retina increases preventing the light to fully reach the retina. For individuals whose eyes keep growing, this means an unstoppable increase in their ophthalmological prescription. (American Optometric Association, 2019). The function that corrective glasses or contacts lenses have is to bend the light before it enters the eye so that the signal is received correctly (Allegro Productions, 2014).

Statistics

According to the study in 2009 by the PhD epidemiologist Susan Vitale, Dr. Robert D. Sperduto, and Dr. Frederick L. Ferris III, the number of myopes in the United States rose from 25% in the early 1970s to 40% by the early 2000s, proving that the prevalence of myopia has increased substantially over the last 30 years. Worse still, the United Nations has projected that by 2050, myopia will affect 52% of the world's population. (World Health Organization, 2015).

When comparing myopia with other refraction errors such as hyperopia (also known as far-sightedness) and astigmatism we can see that all three are present in today's world in an exceptionally large scale. However, these conditions have different impacts, while myopia affects between 20% and 50% of the U.S. population, hyperopia only affects around 10% and astigmatism around 33% (American Academy of Ophthalmology, 2015). This helps illustrate how big of an impact myopia has compared to other eye conditions.

Comparing populations' myopic statistics

A study made by the Iranian Society of Ophthalmology in 2017 reports that in East Asian countries myopia was found to be more common than in South-Eastern Asian countries and in the Americas; while hyperopia had a bigger impact in Africa and the Americas than in Eastern-Asia. According to the study, "South-East Asia and the Americas had the highest and lowest Estimated Pool Prevalence of myopia, respectively (32.9% vs. 16.2%)" (Hashemi H, et al., 2018,

p.5) contributing to the theory of ethnicity playing a significant role in myopia's prevalence and progression. However, in another study made by several Chinese experts in 2015, the contrary was proven. The study analyzed the two largest ethnicities in the Chinese population living inside and outside of the nation. They concluded that ethnicity did not correlate with myopia's prevalence but that the socio-economic status of the population was the major factor instead. They explained that those who had access to a better education and certain privileges were most likely to detect the condition early and treat it with the methods available: corrective glasses, contact lenses, or even surgery (Pan, et al., 2015).

Many other studies have tried to prove ethnicity as an active factor of myopia's prevalence and progression, while others try to find other possible factors instead. Aside their purpose, it is clear that the statistics shown in those studies have determined that a substantial portion of Asia's population has been calculated to have a higher risk of developing nearsightedness, and when that percentage is compared to the Americas' population, a major difference is seen.

Myopia's Origin

A major debate to try to decipher whether nearsightedness is caused by environmental or genetic factors has been active over the years. At first, the genetic factor was seen as the most accurate one but since myopia's prevalence started to rapidly increase through the years, scientists have considered the environment's influence as a potential factor. Recently, scientists have agreed that both options are correct and depending on each case, this could play a crucial role.

Environmental Factor

In the 2015 World Health Organization report published in Sydney, Australia it was communicated that experts linked the environmental factor origin theory with East-Asian populations' high risks of developing nearsightedness. As stated in the report, "… the meeting that the epidemic of myopia in East Asia is primarily due to changes in environmental (social) factors, specifically intensive education and less time spent outdoors." (p.12). Similarly, the Spanish newspaper "El Confidencial" published an article in 2018 supporting the environmental factor as part of this eye condition's origin. In the article, a study made in Ohio in 2008 by optometrist Donald Mutti with eight and nine-year old kids is mentioned as the first study made in the decade in which myopia was observed to develop due to environmental factors. In the study Mutti observed that from the five hundred kids tested, 20% developed myopia during the research process, and the commonality relied on the fact that this percentage of kids did not spend as much time doing outdoor activities as the others. The president of "La Asociación Vision y Vida" (Vision and Life Association), Salvador Alsina, commented for the newspaper that the main explanation found for his relies on the fact that humans are more sedentary nowadays. They engage in many activities during the day that are carried out indoors, this has led their far-sight vision to worsen since it is not regularly used. This could also explain the sudden increase of nearsightedness in the young population over the years since most teenagers nowadays spend excessive amounts of time looking at artificial light and in noticeably short distances. To this, Professor of Ophthalmology at the University of Valencia, Manuel Diaz Lopis commented for "El Confidencial" that sunlight has been proven to stimulate the amount of dopamine in the amacrine cells of the retina. Dopamine is considered the anti-myopia molecule, so when the eye is producing this hormone, the organ does not look for more light, avoiding so the eye's elongation.

Genetic Factor

When considering the genetic approach it is essential to know that Ophthalmologic and Research Professor, Arnold Sorbsy, who initially evaluated the environmental factor and agreed with its approach, but later discovered that the group he was evaluating presented myopia, due to a racial and sex-related tendency for boys over girls, first considered it. Years later his theory was confirmed by Israeli experts; from then Sorbsy became an ardent supporter of the genetic basis of myopia especially since these studies were proven to correlate with Mendelian randomization studies (Morgan & Rose, 2018).

Introduction to Mendelian randomization. As an example of a Mendelian problem using myopia, the following problem is given. Assuming that myopia is given by a recessive allele (n), normal vision would be considered the dominant trait (N). If the parental generation were made from two heterozygotes, the offspring obtained would consist of: 25% Normal vision, 25% myopes, and 50% with Normal vision but carriers of the myopic gene. Of course, myopia is much more complicated than just being a recessive or dominant trait but the purpose of this example was to observe that when solving using Mendel's basic the focus is centered either in one or many traits individually without considering other external factors, by doing this the concentration is put on the genetic information only. This is what Mendelian randomization's purpose is, to evaluate certain traits by focusing in one factor at the time without looking at other correlated factors. Some have asked if a study made by, taking a large group of people and exposing half to the factor evaluated and the other half to the same life conditions excluding the factor would be easier. Reality is that even when less complicated the study would take a longer time making it less practical and also not ethical since that would compromise people's health. Therefore, as better alternative Mendelian randomizations are used instead.

Charles Darwin inclusion in myopia. Darwin's studies tend to mention "Natural Selection" which in an indirect way of referring to what Mendel discovered to be mutations by describing the process that the individual goes through to adapt to their environment for a greater chance of survival. In 2016 PhD Professor of Saint Benedict and Saint John's University, Richard M. Wielkiewicz conducted a study titled "Myopia is an Adaptive Characteristic of Vision: Not a Disease or Defect" describing what he postulated as the "adapted myopia hypothesis" in which he explains that myopia is an example of adaptation due to natural selection. In the study Wielkiewicz states, "myopic individuals may have played important roles in hunter-gatherer groups such as making tools and weapons, and identifying medicinal plants, contributing to individual and group survival." (Health and Medicine, 2017, paras. 2-3) proving that there are other theories and perspectives from which myopia's origin can be evaluated.

Population genetics approach to myopia. Population Genetics is the study of genetic variations within populations, in other words, a combination of Mendel and Darwin's ideas. Population Genetics involve the study of five factors that alter the allele frequency (how often an allele's presence shows within a population). The five factors that could affect allele frequency are: Natural Selection (Alleles for fitter organisms are more frequent); Sexual Selection (Alleles for more sexually attractive organisms are more frequent); Mutations (Variation of alleles due to mistakes in DNA); Genetic Drift (Random changes in the allele frequency); and Gene Flow (The spread of genes between two different isolated populations). A concept that is commonly linked to Population Genetics is "The Hardy-Weinberg Equilibrium" a principle stating that the allele frequency within a population will always remain constant from generation to generation only if no evolution is present. This principle is solely hypothetical and utopian since in any real-life situation at least one of the five factors that alter allele frequency were to be present, but even if

it never occurs it is used as a guidance for scientists to evaluate and compare data to (Evolutionary Biology, 2010).

Using the Hardy-Weinberg Equation. The Hardy-Weinberg Equation is a tool that allows the determination of the genotype of a population without focusing on the phenotype. Maintaining myopia as a recessive trait just like in the Mendelian problem, an example is given. Following the principle, "q" will be determined by the recessive trait and the dominant trait; in this case, a normal vision will be "p." Given the main equation for the principle, it is known that the frequency of the dominant allele plus the frequency of the recessive allele equals one ($p + q = 1$). Now if the BIO 112 population is used, the total members would be *27* (including Professor Leith Adams), if *11* out of those 27 people have myopia, "q" would equal 0.41 or 41% of the population. Now to obtain "p" a simple algebraic calculation of plugging in and subtraction must be done; "p" will then equal 0.59 or 59% of the population. To differentiate between the homozygote dominant and heterozygote the equation needs to be squared, this to obtain the data for two different alleles that each individual has. After squaring the equation the new equation obtained would be $p^2 + 2pq + q^2 = 1$ with "2pq" now representing the heterozygote population. Knowing the values for "q" and "p" it is possible to calculate the percentage for each genotypic trait. Now it is known that there is 16.81% of the myope's trait, 34.81% of normal vision, and 48.38% of normal vision and myope's trait combined.

Living with Myopia

Historic Background

After Aristotle introduced the world to muoops (derived from the Greek words muein which means close, and oops or eye), and after the first spectacles were invented in 1286, myopes lived with no option available for correcting their vision. This was not considered a

priority either, instead many myopes just adapted to living with such condition and were placed to do jobs that required a better near-sight vision such as correcting details in books or illuminating manuscripts. Neil Handley, a museum curator at the College of Optometrists in London commented in an article written last year, "The myopic person, far from being given some correction, was actually encouraged to remain in their myopic condition, because it was actually ideal for them doing this job … This is how societies adapt to what we call disability. They don't necessarily regard it as disability." (Gannon, 2019, para.10). It is almost unbelievable that in the past things were so different.

Options for better Living Conditions

Nowadays the situation is different. Many options are available to treat myopia. The most acknowledged options are spectacles or corrective glasses and contact lenses. According to the American Optometric Association, corrective glasses are the primary choice for most people who are diagnosed with myopia and depending on the severity, either single vision, peripheral or bifocal lens can be prescribed. Contact lenses are prescribed to allow a better view but they also require a more cautious cleaning routine than corrective glasses.

Over decades, scientists have worked to develop new and more advanced alternatives. Some of the most used nowadays include: Orthokeratology, the method in where patients place specialized contact lenses to help shape the cornea over small periods of time; Laser procedures such as PRK (photorefractive keratectomy) or LASIK (laser in situ keratomileusis). Both offered to better the visual impairment by reshaping the cornea and removing small segments of eye tissue with a laser beam light; or other surgery procedures such as inserting optic lenses through a process similar to the cataract surgery (Myopia, 2020). Even with many options available to choose from nowadays, certain impediments such as soaring prices for surgeries restrict many

from accessing certain treatments, forcing a great part of the myopic population to opt for the two most accessible options.

Real Life Story of a Myope's Life

Many myopes worry about the continuous increase in their prescription strength and sometimes wonder if it would ever stabilize. A famous story was published in 2019 by an American mom "Shanna" who published her story for Myopia Awareness Week. She tells her story and mentions the significant impact that nearsightedness has had in her life. While reading, one particular and very impacting statement was given, she stated:

> I once thought myopia was a relatively benign condition and that it was just a part of life … I even thought LASIK or similar eye surgery would correct my vision one day and then I wouldn't have to worry about contacts and glasses… My opinion changed abruptly when, still in my thirties, I developed a vision-threatening condition called myopic macular degeneration. My retina is now permanently scarred near my central vision and since that event I have developed more problems with my eyes. (Cheng, 2019, paras.4-6).

Looking at Shanna's story it is observable that myopia is not just an inconvenience that people live with but also a serious condition that could worsen if the right preventions are not considered. This is the reason why staying informed about myopia and other refractive errors is primordial, as it has been proved that awareness has reduced the risk of blindness and led to vision improvement.

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